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I, Xiang Qin , hereby submit this original work as part of the requirements for the degree of Master of Architecture in Architecture.

It is entitled:

Micro-apartment in Beijing China

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Committee chair: Michael McInturf, M.Arch.

Committee member: Aarati Kanekar, Ph.D.

UNIVERSITY OF Cincinnati

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Micro-apartment in Beijing China

A thesis submitted to the

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requirements for the degree of

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by

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ABSTRACT

Increasing population, lack of available land, and shriveled economic conditions are three of the biggest issues plaguing the metropolis of Beijing, China. These issues have caused a serious drop in the standards of living, forcing architects and engineers to conceive innovative solutions to improve the quality of life for Beijing residents.

The construction of prefabricated micro-apartment towers has fast become a popular trend due to the quick construction process and space saving advantages. By combining the design strategy of the prefabricated Nakagin Capsule Tower with the flexible living space of Domestic Transformer, we can introduce a new generation of customizable apartments.

The highly flexible design of each apartment will allow residents the opportunity to alter and expand the space according to their needs, allowing them to maximize space and improve their living experience. The resulting tower prototype will be a prefabricated and replicable residential tower with replaceable modules inserted via pre-existing slots of the tower structure.

Preface

I visited Steven Holl's Linked Hybrid in Beijing while it was under construction. Though inspiring, it is unaffordable for the average person with costs of more than 24000 RMB per square meter ($1=6.2RMB). Apparent costs are rising rapidly, and the construction of affordable apartments is unable to keep up with the market demands.

My own difficult experience of living in a small dorm with a shared bathroom and shared kitchen amenities has motivated me to come up with a solution to this ever increasing problem.

An affordable apartment is every citizen's right. But beyond that, people also need green open spaces that they can use outside of their own house. I hope to design such an apartment: one that is affordable and provides a better lifestyle for its residents.

Table of Contents

Research - 01

Problem - 02

Background - 04

History of Apartment in China - 06

Precedent - 08

Background Summary - 22

Proposition - 24

Outcome - 26

Client & Culture - 28

Site & Context - 33

Site Location - 33

Climate and natural conditions - 34

Traffic - 37

Context - 38

Site Strategies - 39

Space & Experience - 40

Activities and Functions - 40

Space Standards and Criteria - 42

Design Principle - 44

Design - 45

Ground floor plan - 48

Typical floor plan - 49

Prefabrication - 50

Flexibility - 52

Building section - 54

Facade - 55

Furniture Design - 56

Bibliography - 60

Research

Figure 1 Population in Beijing
Source: http://www.wired.co.uk

PROBLEMS

There are approximately twenty-one million people in Beijing. The population has increased by 38% in the last ten years. More and more people come to Beijing seeking opportunities, but only those with high incomes can afford to buy an apartment within the city. Most have no choice but to live outside the city limits, and are forced to commute over long distances on a daily basis. Some residential areas on the outskirts of Beijing are called "sleepers' towns." You only see the residents when night falls.

A lack of vacant lots and over-population has caused the price of the apartments to sky rocket. Most people cannot afford to buy an apartment in Beijing, and so they have to rent a single room in a shared apartment.

Privacy and safety are basic needs. Renting part of an apartment and having to share the kitchen and bathroom facilities with strangers can make people feel unsafe and allow them little privacy. Most traditional apartments have two or three bedrooms, forcing people to share the space since they cannot afford the entire apartment. Under such conditions, a new type of affordable apartment is needed in China.

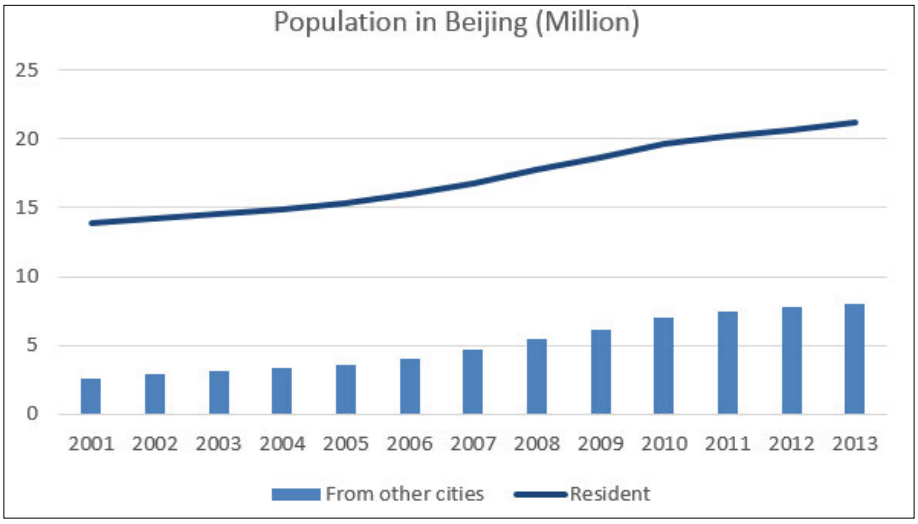


Figure 2 Population in Beijing

Figure 3 Sleepers' town in Beijing
Source: http://www.atyanjiao.com/488.html

BACKGROUND

Beijing, Shanghai and Guangzhou are the most developed cities in mainland China, itself a developing country. Large numbers of people migrate to these cities in search of a better life, causing a massive shortfall of available living spaces. There has been increased construction of substandard apartment towers in the last fifteen years as companies exploit this rising demand. Many people were holding their apartments, and waiting to sell when prices would rise even if they were not in need of the space. But even so, the speed of construction is unable to keep up with the ever increasing demand. On April 30th 2010, the Chinese government passed a restriction limiting the number of apartments owned by a single person in order to control the exploitation. This solution still does not address the underlining problem of increased demand and rising prices.

The traditional size of an apartment is not affordable for the average person and a lack of vacant lots within the city means the new apartment towers have to be built far away from the city. A new type of apartment must be created in order to solve these problems.

Tokyo, London, Manhattan and the other major cities have invested in a new type of apartment building: micro-apartments. Micro-apartments, aptly named, are tiny sized apartments. They are a one-room, self-contained living space that allow its residents their own private space and home. As it is compact, it increases the housing density, saving space while also being affordable. Since it does not require a large plot of land, it is a good solution for the already cramped city of Beijing.

The research is divided into three categories. The first category focuses on the history and culture of apartments in China. The second category is an analysis of small apartments to study their character and spatial experience to identify their successes and defects, in search of the next generation of micro-apartments that may be suitable for modern urban China. The third category is the study of prefabrication, analysis of its advantages and disadvantages, and searching for the best way to build the micro-apartment by using the most advanced technologies.

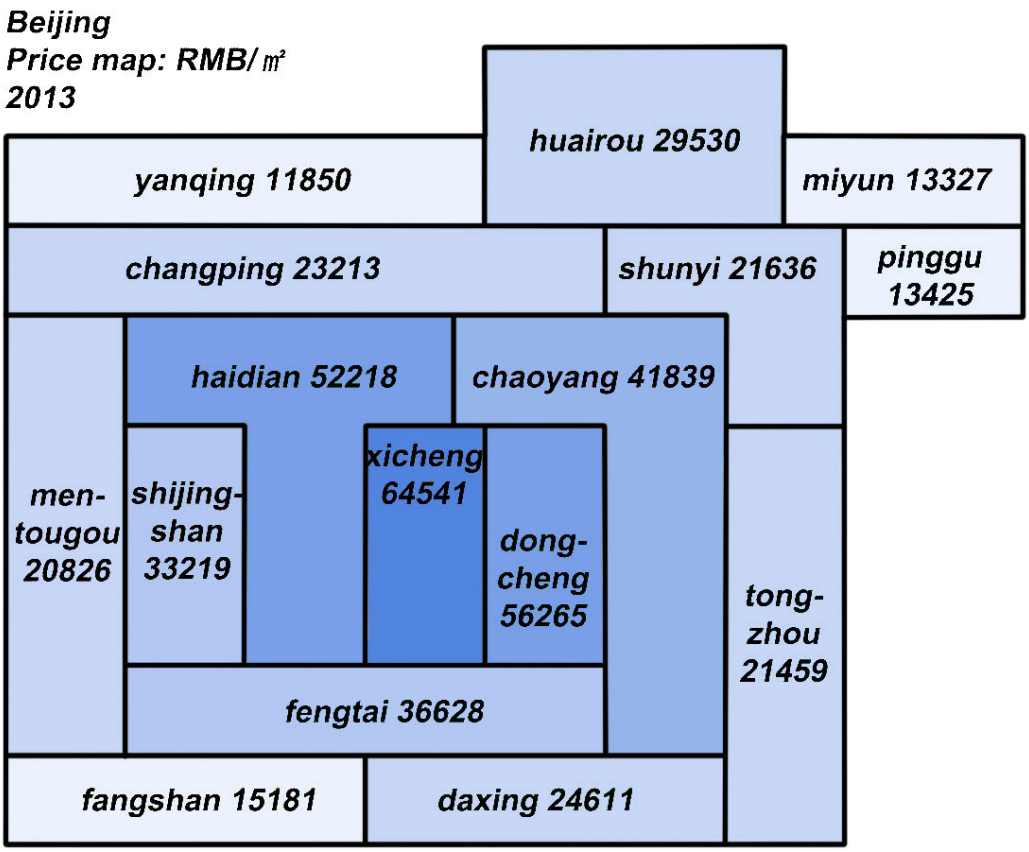


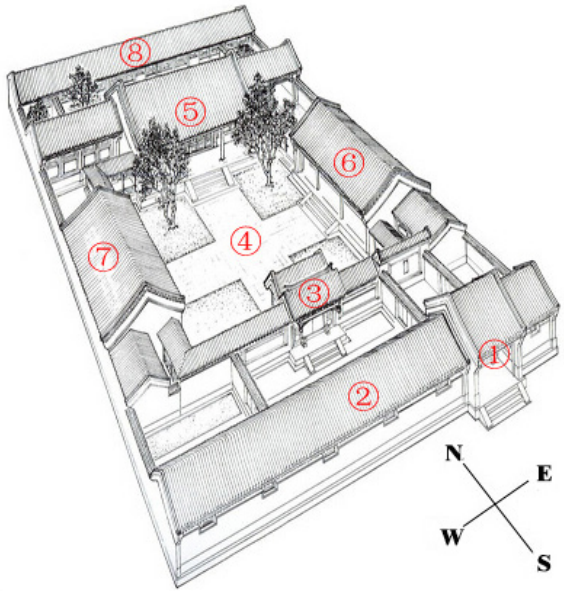
Figure 4 Apartment's price in Beijing

Figure 4 shows the price map for the apartments in different districts in Beijing in 2013. Currently, the average income in Beijing is 5453RMB ($880) per month, which means people who have an average income cannot afford to buy a new traditional apartment. The size of the traditional one bedroom or two bedroom apartments ranges from 80-120 square meter. This is too expensive for all the people who want to live in Beijing.

Apartments in Yanqing, Miyun, Pinggu and Fangshan district are cheap, but they are too far away from the city.

HISTORY OF THE APARTMENT IN CHINA

Under the feudal society, the atrium style house (Figure 5) was introduced and has been flourishing ever since. It is widely known by all the people around the world. They signify the culture of China which is based on etiquette and hierarchy. This is evident in the design principles of the atrium style house and the design principle of the temples and palaces. It was usually occupied by a single large family, but after the founding of new China, most of the remaining atrium style houses are shared by several families. This special living style makes unrelated people living together feel like a big family.



1. Entrance
2. Houses for guests
3. Secondary entrance
4. Garden
5. House for elder
6. House for Children
7. House for Children
8. Mail room or storage

Figure 5 Atrium style house
Source: http://wenku.baidu.com/view/f52fbf224b35eefdc9d33300

During 1840 to 1910, the modern urban house emerged. It is called Shikumen Linong house (Figure 6). This is the early development of urban housing in the semi feudal and semi colonial period. Most of the houses are two stories, post and panel structure with a horizontal courtyard in both the front and back, and the entrance of the house is the typical Shikumen gate.

Figure 6 Shikumen house
Source: Modern Urban Housing in China 1840-2000

From 1911 to 1937, the early development of housing in modern cities was occurring. The Guangdong style houses (Figure 7) were spreading rapidly during that time. It was designed by the Guangdong and Japanese immigrants; small and simple was the concept of the house. This was the first tiny apartment in China, some of the rooms were only a little more than 20 square meters. It was the very beginning of high-rise apartment buildings in China. Apartment buildings which have more than 6 floors with elevators were built in Shanghai. In the next 12 years, China was at war. The quality of living conditions fell rapidly. After the capital shifted from Nanjing to Chongqing the government devised a construction plan, emphasizing industrial construction in the southwest using heavy industry related to military purposes. After the war, the government tried to solve the problem of apartment shortages. As a result the semi-temporary, low-rise apartment and dormitory-like apartment became the most popular. After the Cultural Revolution, the apartment history progressed to a new phase. The developing speed of the apartment was extraordinary. Under the socialist market economy since 1992, the designers adopted the design principals from the developed countries. Townhouse and high-rise apartment are widely built. They have become the symbol of the modern city.

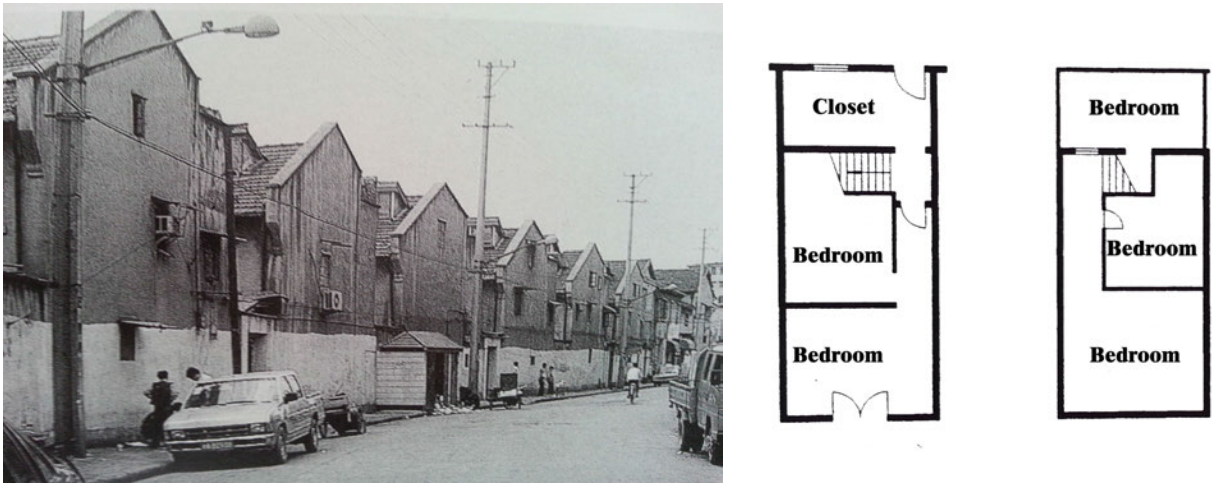


Figure 7 Guangdong Style House
Source: Modern Urban Housing in China 1840-2000

PRECEDENTS: NAKAGIN CAPSULE TOWER

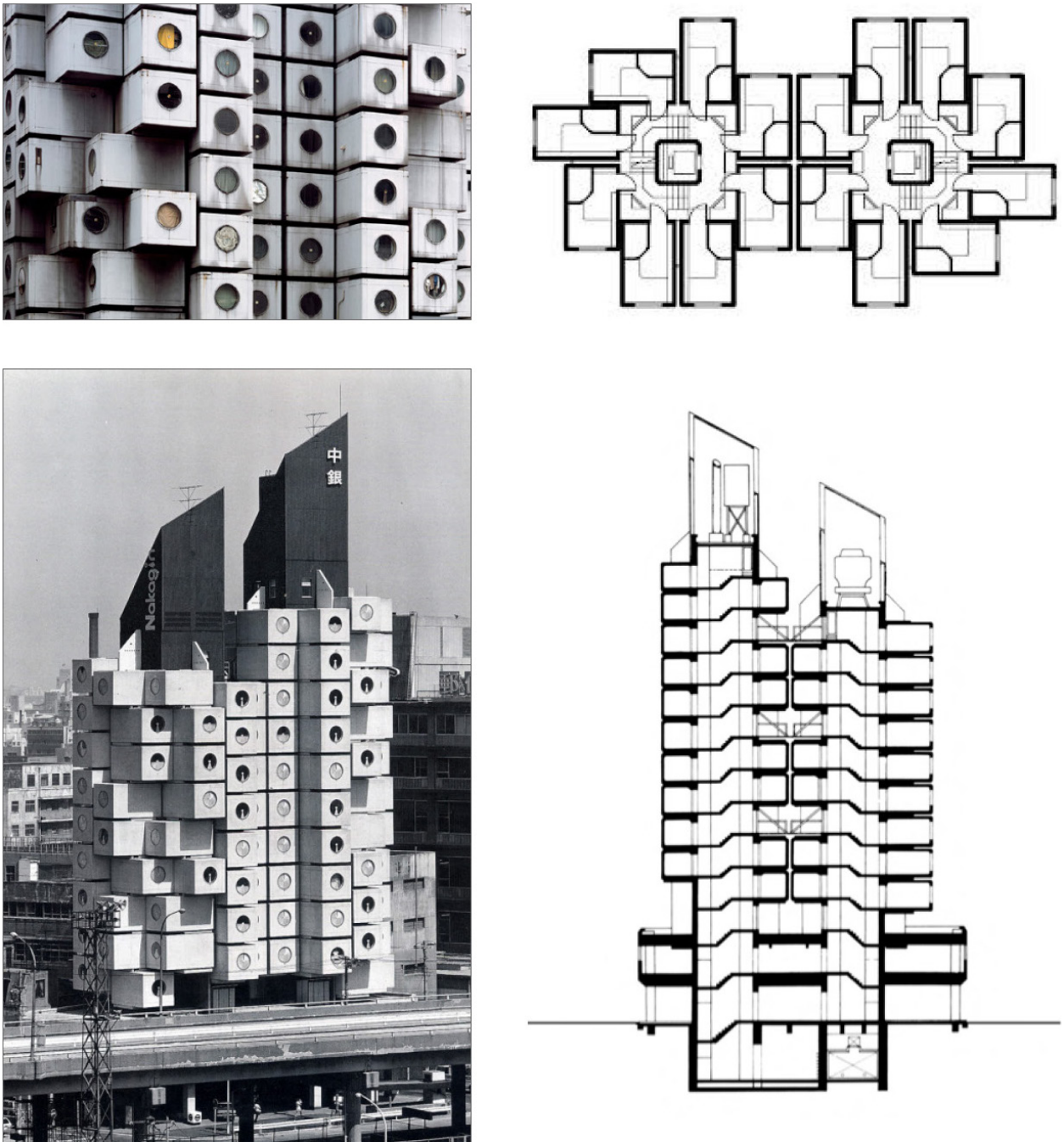


Figure 8 Nakagin Capsule Tower
Source: https://coppersection.files.wordpress.com/2014/02/nakagin-capsule.jpg

Nakagin Capsule Tower (Figure 8) was designed by Kisho Kurokawa and constructed in 1972 in Ginza, Tokyo, Japan. It is the world's first capsule style architecture built for residential use. Kurokawa developed the technology to install the capsule units into a concrete core with only 4 high-tension bolts, as well as making the units detachable and replaceable. There are 140 units in the tower and all of them are prefabricated in the factory, and then installed on site.

However, in 2013, there are only 30 units still being used as apartments. The rest of them are used as offices, storage, or are simply wasted (Figure 9). The real estate firm of the tower is closed and the community members want to take down the building and replace it with another modern building.

Why did the Nakagin Capsule Tower fail less than half a century after it was built? The economy is one of the issues. Although based on the design, every unit is able to be replaced, one would have to order the very unique unit from the factory and use a crane to install it on site. If one orders large numbers of units from the factory then it will be cheap, but if one only orders one unit it will be extremely expensive. So the budget of the entire replacement process is too costly for any individual client. It was estimated in 2006 that it will cost around 6.2 million yen (~50,000 U.S. dollars) to renovate a single unit. Another big issue is the size of the unit. Every single unit is 2.5 meters by 4 meters (Figure 10 & 11). The space is too limited for the clients.

Figure 9 Unit in 1973 & 2013
Source: www.google.com

What this thesis will take from the Nakagin Capsule Tower is the concept of prefabrication; replaceable units and the steel structure of the units. The technology that allows a 4 meter long unit to hang on the column is amazing. Although it is not a successful micro-apartment building for people to live in, it is an icon in the history of apartment design. Many other micro-apartment designs are still using the same concept.

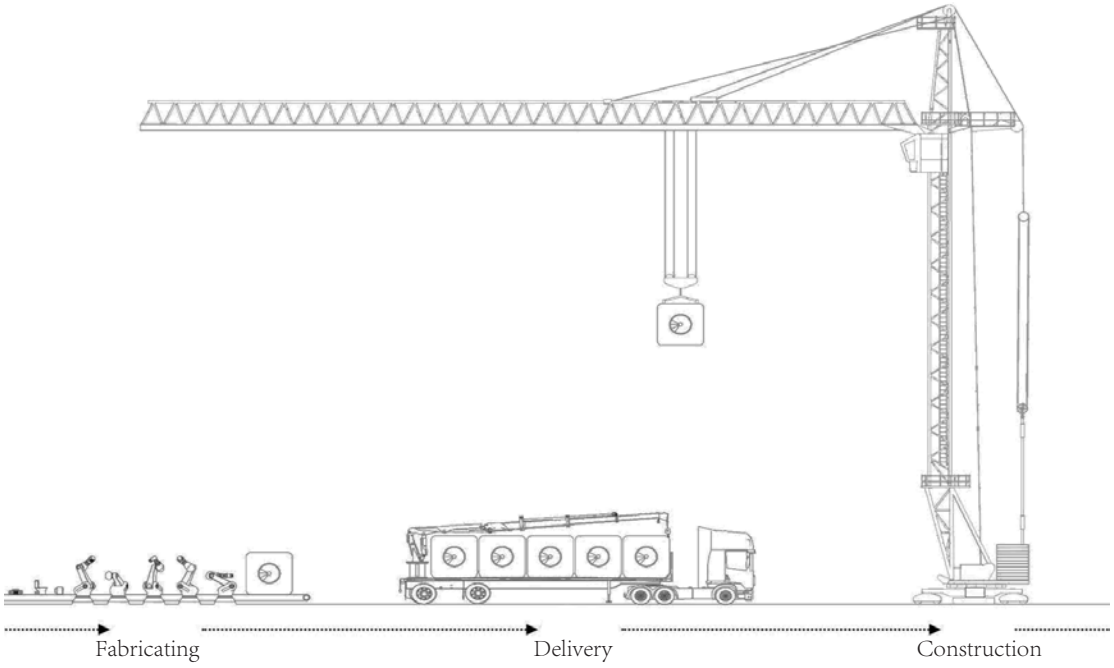
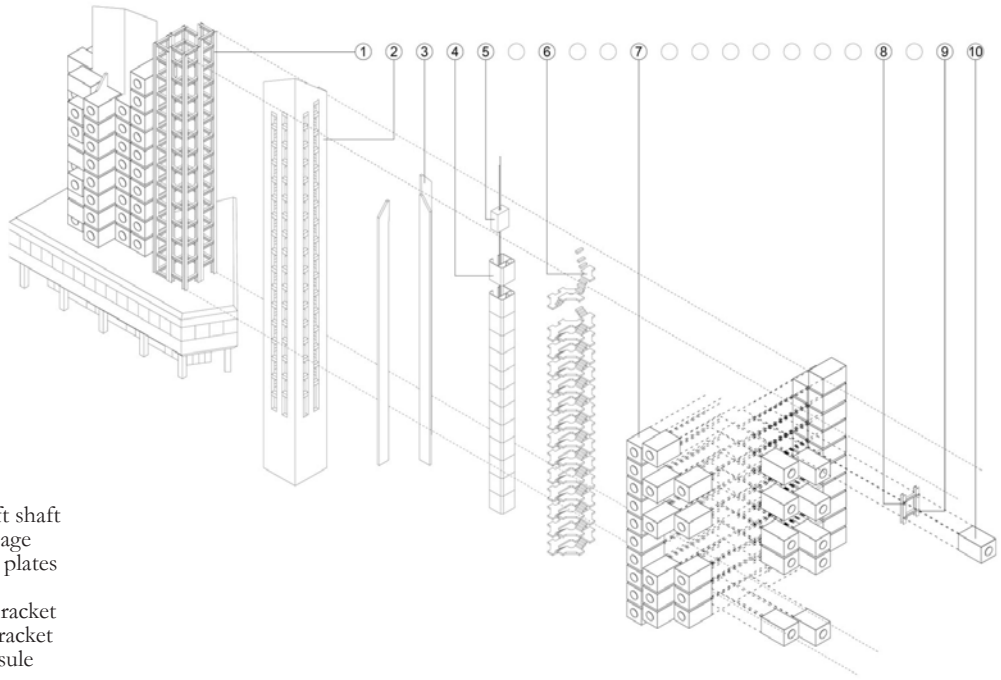


Figure 10 Prefabrecation
Source: http://mwarchitcture.blogspot.com/2009/11/prefab-nakagin-capsule-tower-kisho.html



1. steel frame
2. insitu concrete
3. plug-in service fins
4. pre-cast concrete lift shaft
5. pre-fabricated left cage
6. pre fabricated floor plates
7. capsule cluster
8. upper connection bracket
9. lower connection bracket
10. pre-fabricated capsule

Figure 11 Prefabrecation
Source: http://mwarchitcture.blogspot.com/2009/11/prefab-nakagin-capsule-tower-kisho.html

PRECEDENTS: MY MICRO NY

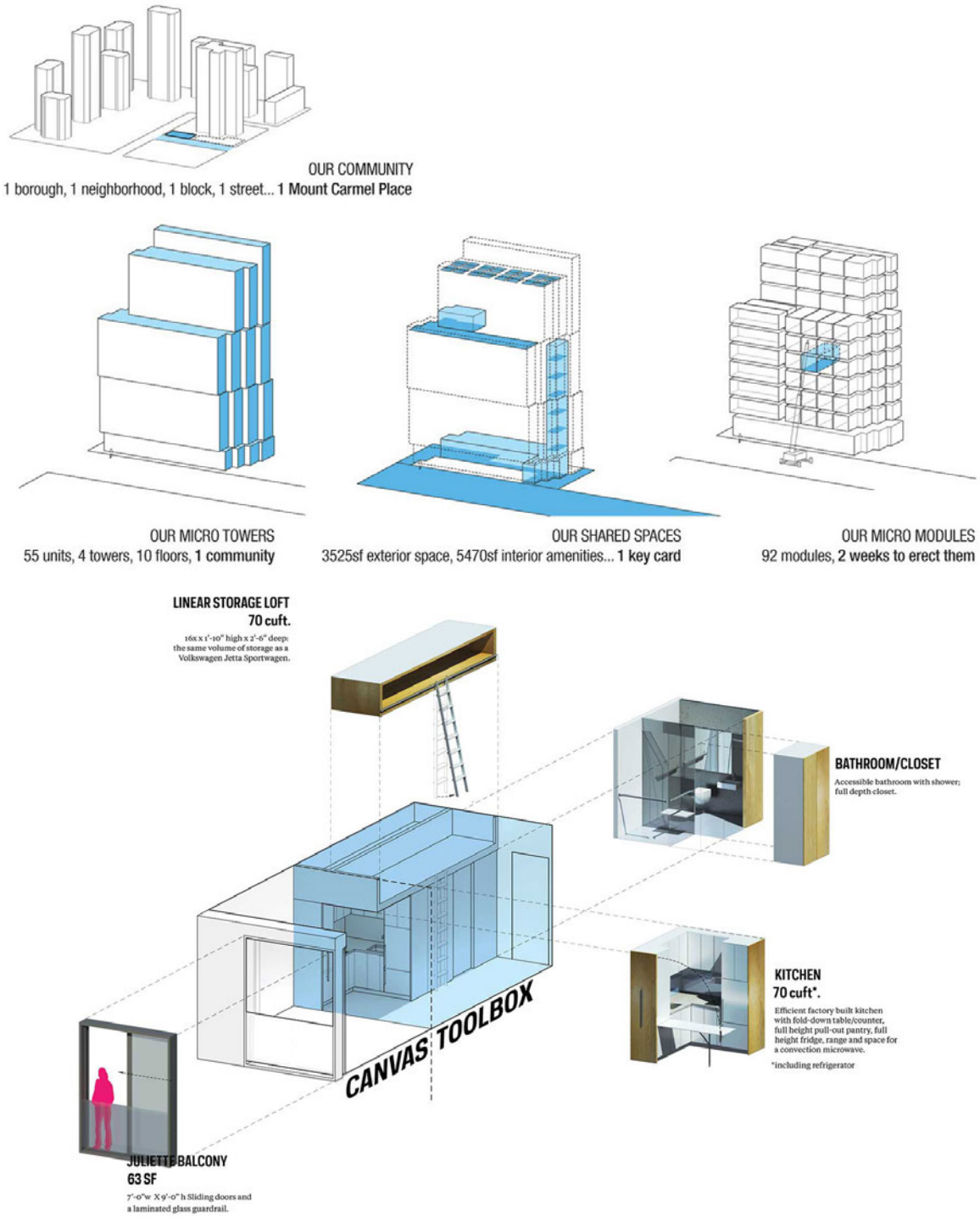


Figure 12 Unit analysis
Source: http://narchitects.com

My Micro NY is a project worked on by nARCHITECTS. It is located at E 27th St, Manhattan, NY. The construction began at the end of 2013 and the residents are expected to move in by September 2015. This project has 55 new micro-units. They are 23 to 34 square meters and affordable for low and middle income people. The concept of the design is to use prefabrication and modular design to significantly shorten the project schedule and save on the financing and conventional construction costs. Figure 12 is the unit perspective. It is separated into two parts. In the toolbox, the storage, bathroom, closet and kitchen are integrated together. Miscellaneous furniture, such as beds and desks, are in the canvas.

The inspiration taken from this project is the modular design and how it can be adapted to any site. Unlike many other micro-apartments it has varying sizes of units. Which means it gives the clients more choices. Compared to the Nakagin Capsule Tower, the concept of prefabrication and replaceablility remains intact. The innovation in this project is the modular design and it deeply considers the human factors in the tiny apartment. On the other hand, based on the information of the Nakagin Capsule Tower, replacement of an entire unit in the future will be expensive.

Figure 13 My Micro NY
Source: http://narchitects.com

PREFABRICATION

"Mass production was the ideal of the twentieth century. Mass customization is the recently emerged reality of the twenty-first century."

Stephen Kieran and James Timberlake, from the introduction to Refabricating Architecture

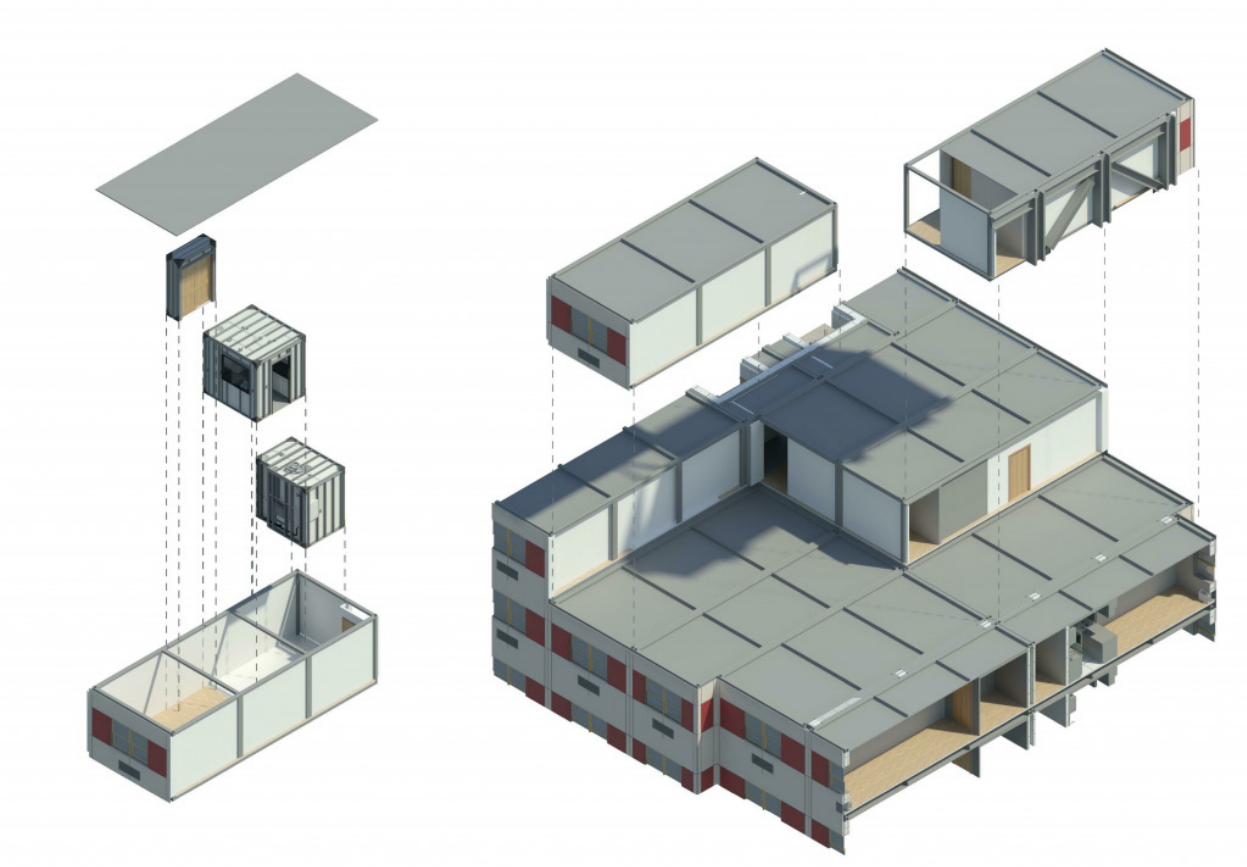


Figure 14 prefab
Source: http://www.modularhomecoach.com

According to the research, we can see prefabrication is used on both micro-apartment designs. Furthermore, in the last half century prefabrication has been more widely used in architecture. Based on the research the primary advantages of prefabrication are:

Shorter construction time; cost effective solutions; safety in construction; an increase in the quality of construction; reduction of construction waste; environmentally friendly way of building with optimum use of materials; recycling of waster products; less noise and dust.

The disadvantages of it are: leaks can form at joints in prefabricated components; transportation costs are high; large prefabricated sections require heavy-duty cranes and precision measurement and handling to place in position.

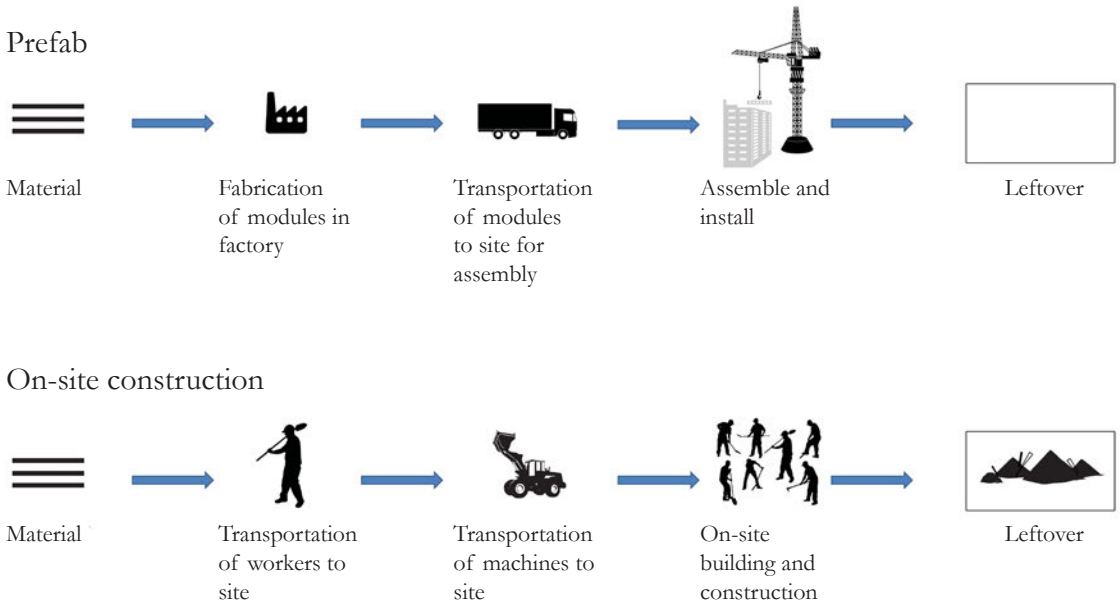


Figure 15 prefab vs on site construction

PRECEDENTS: HUNAN DONGTING LAKE HOTEL

In 2013, a prefabrication video on the internet became famous. It is the Hunan Donting Lake Hotel video (Source: https://www.youtube.com/watch?v=hhM6Mc5x4Yw). After the foundation is ready, the 200 construction workers spent only 360 hours to install the entire 30 floor hotel. The Broad Group Construction company claims that the 17,000 square meter tower is 5 times more energy efficient than the competition and generates a fraction of the waste. And it can withstand up to a 9M earthquake.

"BROAD Group is an enterprise based on the vision of unique technologies and the tenet of preserving life. All BROAD products and services are essentially optimizing human life and the environment of the earth.

BROAD Sustainable Building Co. Ltd. provides factory-made sustainable buildings featuring 90% pre-fabrication, 5 times more energy efficiency, 99% PM2.5 filtration as well as no collapse in 9-magnitude earthquake."

Source: http://en.broad.com/index.html

Figure 16 Hunan Dongting Lake Hotel
Source: http://en.broad.com/

Figure 17 is the detail process of the prefabrication: First, they prefabricate the structure and ceiling in the factory. Second:, the workers put the pipes and ducts through each floor module while it is still in the factory. Third, they build the concrete floor and put the floor material above it. Fourth, modules are brought to the site, each with all the necessary columns, bolts, tools and other peripherals for connection and installation. Fifth, each section is lifted into place by crane workers who use the materials on the module to connect the pipes and wires quickly. Sixth, they install all the windows on the facade. Steps five and six only cost the workers 360 hours. This process is amazing. But as a prefabrication building, it still has its weakness. The disadvantage of this is that the height of the columns can be no more than 4 meters. And this 30 floors building requires a big size factory and storage area to prefabricate and store all the pieces. However, 4 meters is wide enough for the micro-apartment.

Figure 17
Source: http://en.broad.com/

PRECEDENTS: CASULO

How to maximize the space usage in a small apartment is the real challenge faced by all designers. Furniture plays a very important role in micro-apartment. Transformable furniture is widely used to create space.

CASULO is a box with the base area of a euro-pallet, only 90 cm high. Inside it are an armoire, a desk including a container, a height adjustable stool, two more stools, a shelf, and a bed with mattress. All together, ready to set up without any tools in just a few minutes and without any piece leftover. And it can be disassembled anytime you want, ready to remove, without additional packaging materials.

The creativity in this project is great. All the basic furniture is coming out from one box. This is good for people who only need to live there for a short time and travel a lot, because it's small, cheap and easy to ship to another apartment. However, for people who will live in the apartment as their home for a long time, this furniture is too simple, it cannot create the "dream home" feeling. Each person has their own dream home, which means each apartment is a single project to the designer. Furthermore, the color of it gives people the feelings of modern, but the material seems too fragile as furniture.

"The Casulo is for people on the move, those in job training, students, and people who have to change their location frequently. "

Source: http://www.mein-casulo.de/en/casulo_is_what.htm

Figure 18
Source: http://www.mein-casulo.de/en/casulo_photos.htm

PRECEDENTS: DOMESTIC TRANSFORMER

Domestic Transformer is another micro-apartment with transformable furniture. It is located in downtown Hong Kong, China. The designer Gary Chang is the owner of the apartment and he has lived here since he was a little kid. The concept of the project is using shifting wall units suspended from steel tracks bolted into the ceiling, and by doing so the apartment may become all manner of spaces — kitchen, library, laundry room, dressing room, a lounge with a hammock, an enclosed dining area or even a wet bar. And the shifting walls are the sliding shelves. The success of the project has created all manner of spaces in only one small room by using the sliding walls, and it also creates the "dream home" feeling for the user. However, as a concrete structure apartment, the structure system for the sliding walls requires space on the celling to hide the tracks. And compared with other same size micro-apartments, the renovation cost is much higher. But home is different than any other project. People would like to live there for decades or their entire lifetime. So the clients' needs become extremely important when considering the design.

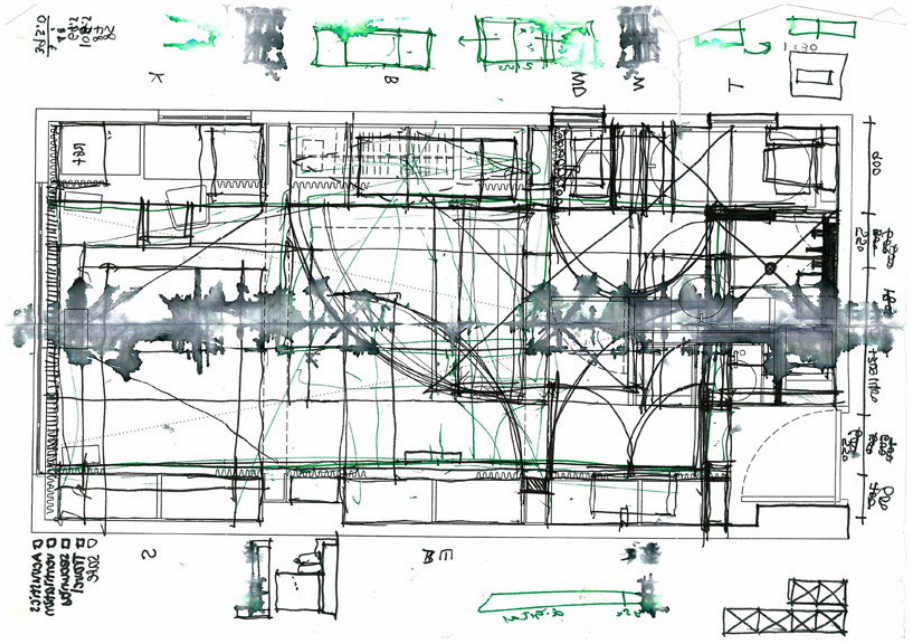


Figure 19 Original Sketch
Source: http://www.designboom.com/architecture/gary-chang-on-urbanism-and-his-metamorphic-apartment/

"I don't mean this from an angle of eco-design, but somehow we touch on that by simple reduction. How big do you need a volume at different times? This is a very good example of flexibility in the sense of blurring the boundary of public and private, or simply [architecture as] a device able to adapt for change. " by Gary Chang

Figure 20 Interior
Source: http://www.nytimes.com/slideshow/2009/01/15/garden/20090115_HONGKONG_index.html

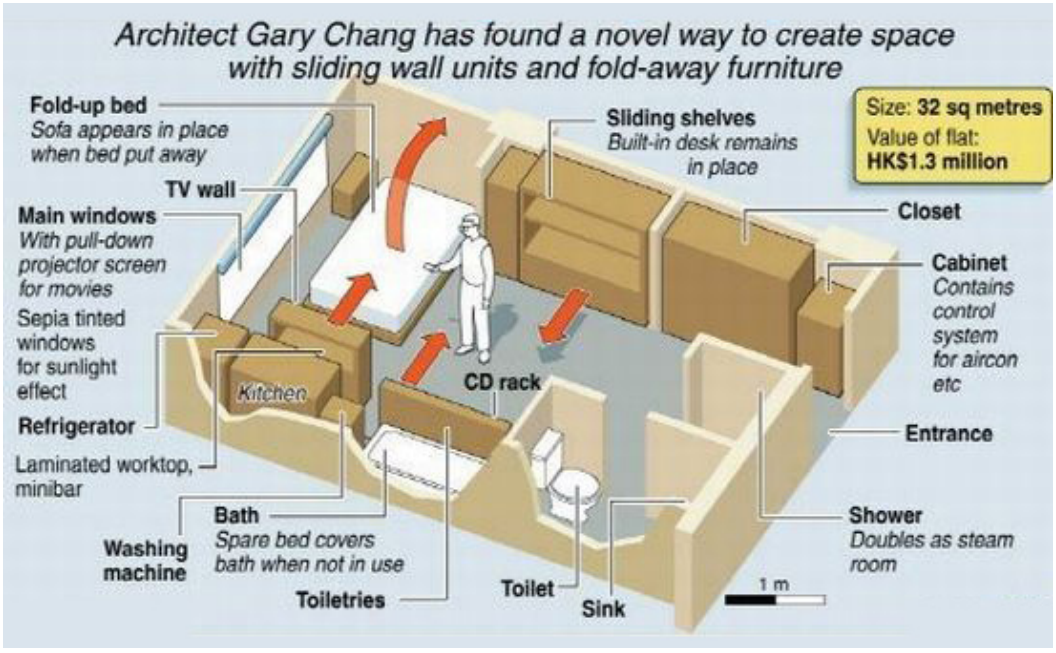


Figure 21 Analysis
Source: http://www.archivenue.com/gary-changs-24-rooms-in-a-32sqm-apartment/

BACKGROUND SUMMARY

The needs of the market are driving all the designs. Under the socialist market economy, the real estate firms in China prefer to build residential buildings which have a huge community center and spacious apartments such as the linked hybrid which is located in Beijing and designed by Steven Holl. That is because, based on the history of apartments in China, they can make more money from it. At the same time, all clients want to live in the best conditions possible, such as those offered in large modern apartments. This is the basic need of most people and the dream urban lifestyle they wish for. But this kind of apartment is not easily affordable in the metropolis. So in response to these situations, exploring a new type of apartment to adapt to people's current and future needs is very important.

The apartment in the Linked Hybrid is 86 sqm to 420 sqm. It is not affordable, and it requires a large size of vacant lot.

Figure 22 Linked Hybrid
Source: http://inhabitat.com/linked-hybrid-housing-development/

High income people can afford a good apartment. Low income people, however, will have to live together in a small apartment with bad conditions (Figure 23). However, medium income people want to have their own apartment but the economy is the biggest problem(Figure 24).

Figure 23 Living together
Source: http://www.wenxuecity.com/news/2013/02/25/2252181.html

Figure 24 Income and apartment

PROPOSITION

According to the research, existing micro-apartments all have something in common. First of all, they are all located in metropolitan areas, because of the needs of the market. In metropolitan areas, the vacant lots are limited for apartment towers but the population is rising very fast. In this case, the micro-apartment is one of the solutions to solve the problems. Second, prefabrication is used to lower the budget costs of the building since the technology developed allows the mass production of the units. The design and selling of the micro-apartment in modules as a finished product will be the next generation of apartment living. It can not only lower the budget but also shorten the construction time. You can order it online, and have it delivered to your new home.

According to precedents, we understand that the best way to create space in a micro-apartment is by using transformable furniture. It will create more possibility for use of space in the tiny apartments and allow the chance for the resident to customize their "dream home." In the meantime, the concept of "replacement" is widely used in micro-apartment design, but in reality it will be too expensive to replace the entire unit. The reason we need to replace it is to upgrade it to a new form to adapt the needs of the clients. However, we can instead create the opportunity to replace part of the unit in order to meet the needs of the client and it will not be too expensive.

When the client goes into the Apple store to buy an iPhone, he can choose different sizes, colors and memory cards for it to suit his needs and affordability. To design the apartment as a product, we should give the clients a similarly extensive list of options. In traditional design, the designers design everything for the client. But here, the interior will be left for the client to fashion into their dream home. In the new generation of micro-apartments we are providing multiple choices for the interior decoration to the clients, while also giving them a choice for their facade. It is up to the client choosing their favorite style of decoration on the exterior. Flexibility will be the key concept of the design.

Figure 25 Micro-apartments tower concept
Source: http://t.zhulong.com/u101/worksdetail4417010.html

OUTCOME

This project will be an affordable and highly flexible prefabricated micro-apartment tower.

The residential tower is the principle part of the project. Other amenities are services for the residential groups and the potential user who is living or working around the tower. All the amenities will be on the ground floor and their functions are based on the needs of the community.

To meet the needs of different sized families in different living conditions, there are three typical sizes of basic unit plans. Each plan is separated into two parts. One of them is fixed within the bathroom, kitchen, ducks and pipes inside; another part is the flexible part, and it can be replaced in the future to fulfill the client's needs.

In order to make the client satisfied, large numbers of window styles have been provided for them to choose from. The client can also choose the pattern, color, material and ornament on the façade of their own apartment. Those are all easily replaceable in the future with the permanently attached crane on the roof of the tower.

The mini crane in Figure 26 is called a spider crane. It can be used to install and replace the replaceable part of the micro-apartment.

Figure 26 Spider Crane
Source: http://www.klclutch.com

Figure 27 Outcome concept
Source: www.voiceofsandiego.org

Client & Culture

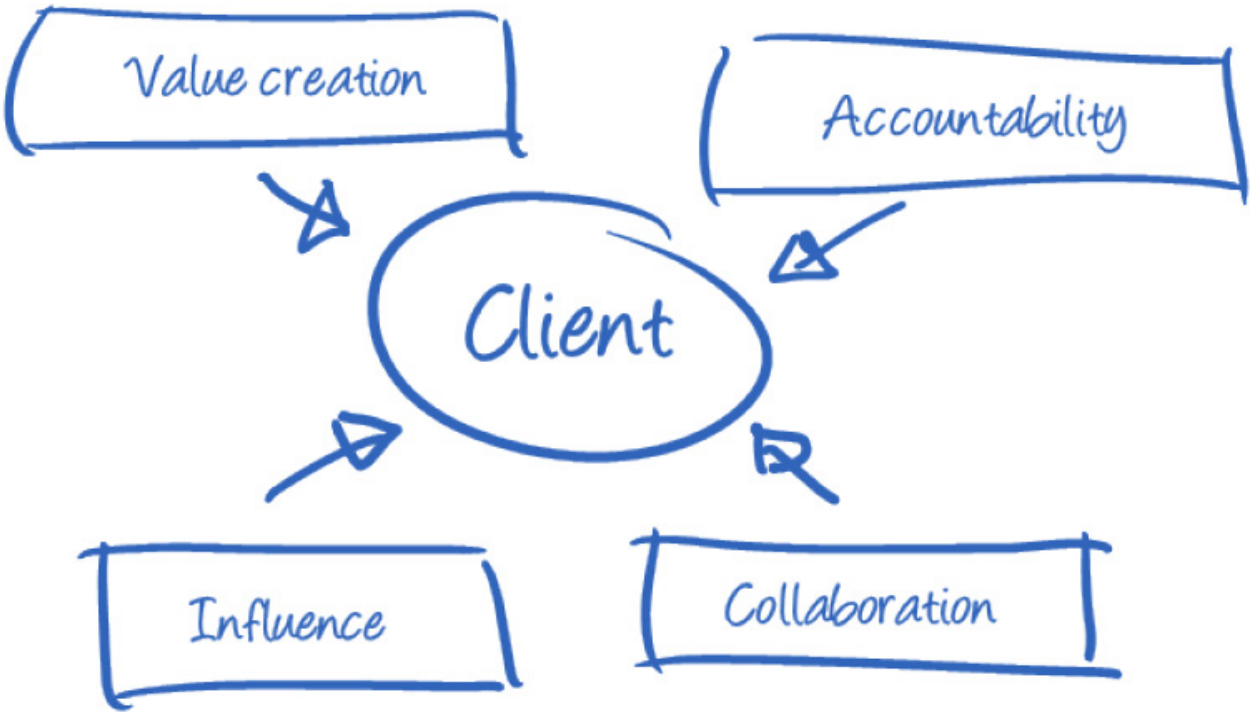


Figure 28 Client & Culture
Source: www.arcadiaconsulting.co.uk

APARTMENT

There are two types of apartments in Beijing. One is the new apartment (Figure 29), and it still follows the design principle of residential towers. Most of them have three types of units: one bedroom, two bedrooms and three bedrooms. The location of the apartment is far away from the city, so the price is lower than the apartment in the city. In recent years, most of the new apartment towers were built outside of the city so the clients can afford it even if it means the client has to spend a long time on commute every day. Economic issues force the clients to buy the apartment outside the city, which is the reason Beijing has "sleepers' town".

In the meantime, the old apartments (Figure 30) in the city are also for sale. The owner of the apartment sells the apartment to make money. The price of it is really high, even though the condition of the apartment is not good (built in 1960's or 1970's), but the location of the apartment ensures its price will never be cheap.

Figure 29 New apartment
Source: newhouse.fang.com

Figure 30 Old apartment
Source: money.163.com

CLIENTS

Based on the history of other metropolitan areas, the micro-apartment is the solution needed to solve the population and economy issues. The society issues happening in Beijing already happened in other metropolitan areas in other countries. We can separate the people into three groups. The first group will be workers who have high-stress jobs to sustain their family finance. For those people, they will have their parents and children needing to be taken care of. They need a tranquil and private space for themselves. They consider their living space as a place for relaxation and sleep. The second group will be the retired seniors, who stay at home most of the time, and they will take care of the child in the daytime, and sometimes do the household work as well. What they need is the common space for knowing neighbors and community development. The third group will be young people, who prefer high-rise living and do most of the activities outside the living place, and in the meantime they do not have much income.

Figure 31 Clients
Source: Urbandencity: Highrise, high-density living in Shanghai, by Cheng James Zhou

NEEDS

The clients of the micro-apartment will be young professionals in the third group who want a city life in Beijing, especially the people who come from other cities and the people who will be getting married soon. The new micro-apartment is different from the traditional apartment, as it is a dorm-like tiny apartment. In China, the student studying in undergraduate or graduate school will live in the student dorm, so they can easily accept the dorm style apartment. It is very easy for young people to accept new things; they will feel it is a modern style to live in the micro-apartment and it will be "self-actualization" if they have their own apartment in Beijing.

In 2013, around 8 million people migrated to Beijing seeking a new life. From the Maslow's hierarchy of needs chart (Figure 35), we can see that for all the people, the most basic need is "safety". After that people will try to get "love", "esteem" and "self-actualization". For the young people who just graduated from school, they are seeking their dream life. After years of working hard, they all want a change. They want to be part of the urban life. An apartment will be the first goal for them.

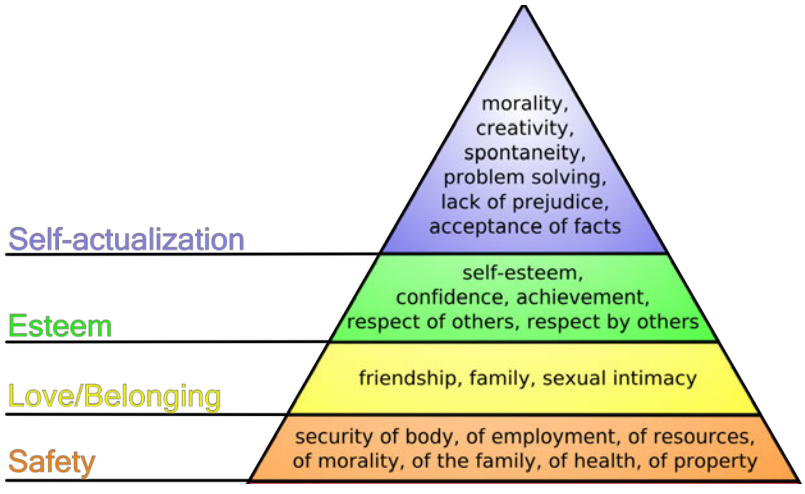


Figure 32 Maslow's hierarchy of needs
Source: www.google.com

CULTURE

How can young professional people buy an apartment? Most of the time their parents must help. Nowadays, in China, under the one child policy, most young people live with their parents until they get married or they moved to another city to seek a new style of life. Most of the people who were born in Beijing already have their own home, even if it means living with their parents. In the Chinese culture living with your parents and taking care of each other is very common. Unlike America, most of the grandparents in China will take care of their grandchild for a long time, sometimes until the grandchild becomes an adult or the grandparents pass away. Most elderly people refuse to go to any institutions for the elders, because in their mind, it is a place for people who are poor, old and who do not have a child to care for them. For a new couple, having their own home is necessary for a lot of reasons. If they can, most of them will choose not to live with their parents after they get married because they want their own space and independent life. Most young professional are the only child in their family, so their parents will not hesitate to help them with the down payment of the apartment. The rest of the apartment fee will be from a loan from the bank.
The micro-apartments do not need a large site to build which means that even in the metropolitan areas we can still find some empty sites. In the city of Beijing, there are some vacant lots which are not large enough to build the most popular style of apartment towers like Linked Hybrid. But it is enough for the micro-apartment tower. The smallest size of the micro-apartment tower will be one unit per floor. So under this condition we can build many micro-apartment towers in the city.

Site & Context

39°54'01.2"N, 116°33'59.0"E

The site is in the city of Beijing. The total area is about 2400 square meters.

Beijing is one of the most developed cities in China, and is the capital city of China. The permanent population there is over 21 million which includes 8 million of people that commute from another city. The large population has caused severe air and noise pollution and brings traffic problems.

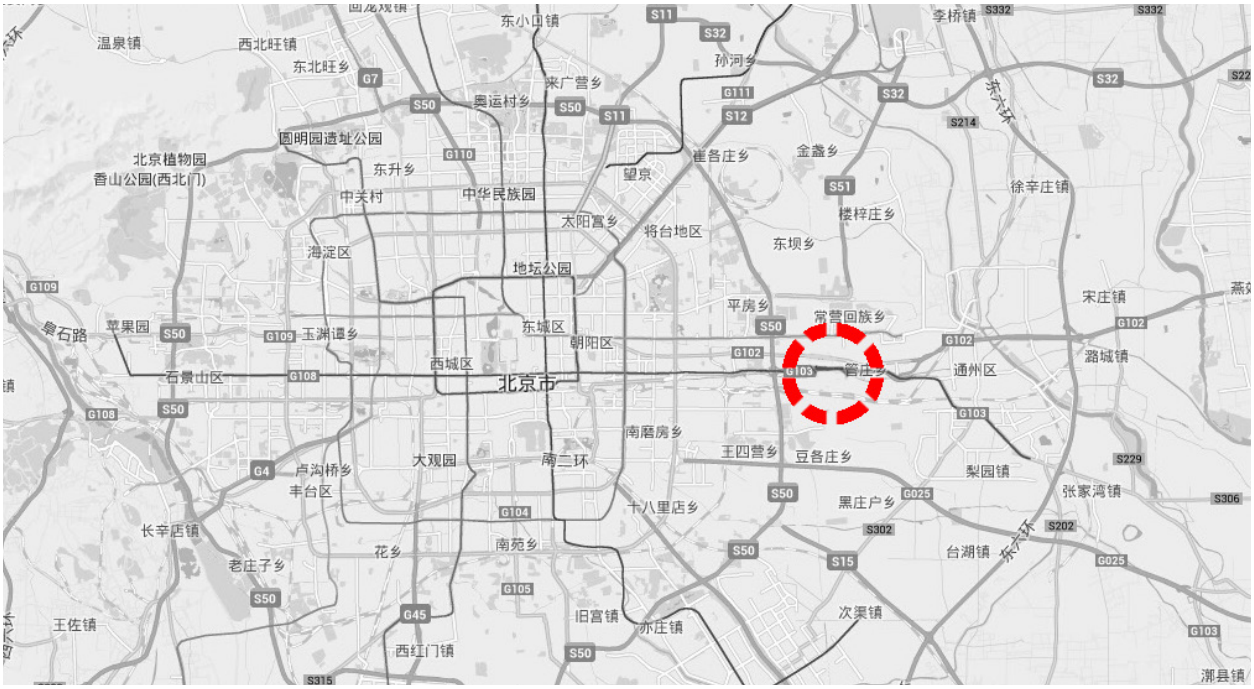


Figure 33 Site Location

CLIMATE AND NATURAL CONDITIONS

Beijing is hot in the summer and cold in the winter which includes several bad natural conditions, such as sand storms, PM2.5 pollution and a lack of water.

"Beijing has a rather dry, monsoon-influenced humid continental climate, characterized by hot, humid summers due to the East Asian monsoon, and generally cold, windy, dry winters that reflect the influence of the vast Siberian anticyclone. Spring can bear witness to sandstorms blowing in from Gobi Desert across the Mongolian steppe, accompanied by rapidly warming, but generally dry, conditions. Autumn, like spring, sees little rain, but is crisp and short. The monthly daily average temperature in January is −3.7 °C (25.3 °F), while in July it is 26.2 °C (79.2 °F). Precipitation averages around 570 mm (22.4 in) annually, with close to three-fourths of that total falling from June to August. With monthly percent possible sunshine ranging from 47% in July to 65% in January and February, the city receives 2,671 hours of bright sunshine annually. Extremes have ranged from −27.4 °C (−17 °F) to 42.6 °C (109 °F). "(Source: en.wikipedia.org/wike/Beijing)

Beijing China

	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov.	Dec.	year
Highest ℃（℉）	14.3 (57.7)	19.8 (67.6)	29.5 (85.1)	33.0 (91.4)	38.3 (100.9)	40.6 (105.1)	41.9 (107.4)	38.3 (100.9)	35.0 (95)	31.0 (87.8)	22.0 (71.6)	19.5 (67.1)	41.9 (107.4)
Average high℃（℉）	2.0 (35.6)	5.7 (42.3)	12.3 (54.1)	20.7 (69.3)	26.7 (80.1)	30.5 (86.9)	31.4 (88.5)	30.3 (86.5)	26.2 (79.2)	19.4 (66.9)	10.2 (50.4)	3.8 (38.8)	18.3 (64.9)
Average ℃（℉）	−3.1 (26.4)	0.2 (32.4)	6.7 (44.1)	14.8 (58.6)	20.8 (69.4)	24.9 (76.8)	26.7 (80.1)	25.5 (77.9)	20.7 (69.3)	13.7 (56.7)	4.9 (40.8)	−1.1 (30)	12.9 (55.2)
Average low℃（℉）	−7.5 (18.5)	−4.5 (23.9)	1.3 (34.3)	8.8 (47.8)	14.8 (58.6)	19.6 (67.3)	22.5 (72.5)	21.5 (70.7)	15.8 (60.4)	8.6 (47.5)	0.3 (32.5)	−5.2 (22.6)	8.0 (46.4)
Lowest ℃（℉）	−22.8 (−9)	−27.4 (−17.3)	−15.0 (5)	−3.2 (26.2)	2.5 (36.5)	9.8 (49.6)	15.3 (59.5)	11.4 (52.5)	3.7 (38.7)	−3.5 (25.7)	−12.3 (9.9)	−18.3 (−0.9)	−27.4 (−17.3)
Precipitation㎜（英寸）	2.7 (0.106)	4.4 (0.173)	9.9 (0.39)	24.7 (0.972)	37.3 (1.469)	71.9 (2.831)	160.1 (6.303)	138.2 (5.441)	48.5 (1.909)	22.8 (0.898)	9.5 (0.374)	2.0 (0.079)	532.0 (20.945)
Humidity （%）	43	42	42	44	50	59	71	73	66	59	53	47	54.1
Average rain day（> 0.1 ㎜）	1.8	2.2	3.3	4.9	6.4	9.7	12.9	11.4	7.5	4.9	2.8	1.8	69.6
Daylight hours	189.0	192.1	228.2	244.5	267.9	238.2	202.7	209.3	215.3	211.5	182.0	175.2	2,555.9

Figure 34 Climate
Source: http://en.wikipedia.org/wiki/Beijing

DUST STORMS AND PM 2.5

The dust storm is one of the biggest weather enemies in Beijing. The air pollution levels went off the charts when strong winds blew a dust storm across the region. In the first four months of 2006, there were no fewer than eight dust storms. In April 2002, one dust storm alone dumped nearly 50,000 tons of dust onto the city before moving on to Japan and Korea.

The most dangerous air pollution is the PM 2.5. A team of researchers at Columbia University, in collaboration with Yale University, recently used satellite readings to produce data on fine particulate concentrations in Chinese provinces. They provide the first estimates of ground-level annual average concentrations of the pollutant PM 2.5 for all of China over the last decade. PM 2.5 is the term for particulate matter measuring 2.5 microns or less in diameter and has become a focus of public safety campaigners in China in recent months. Fine particulates have the ability to penetrate human lung and blood tissue and can lead to asthma, cardiovascular disease and cancer.

Figure 35 Dust storm
Source: www.zhaojiaoyu.cn

In March 2015, there is a reporter named Jing Cai in China who worked for the CCTV upload her research about the PM2.5 online. The Video is called "Under the Dome" (https://www.youtube.com/watch?v=T6X2uwlQGQM), and it showed how bad the air pollution is in China and what causes it. The government is trying to improve the air quality in China now. The air quality cannot be suddenly improved overnight, and as such, an air pure system and green space are especially needed.

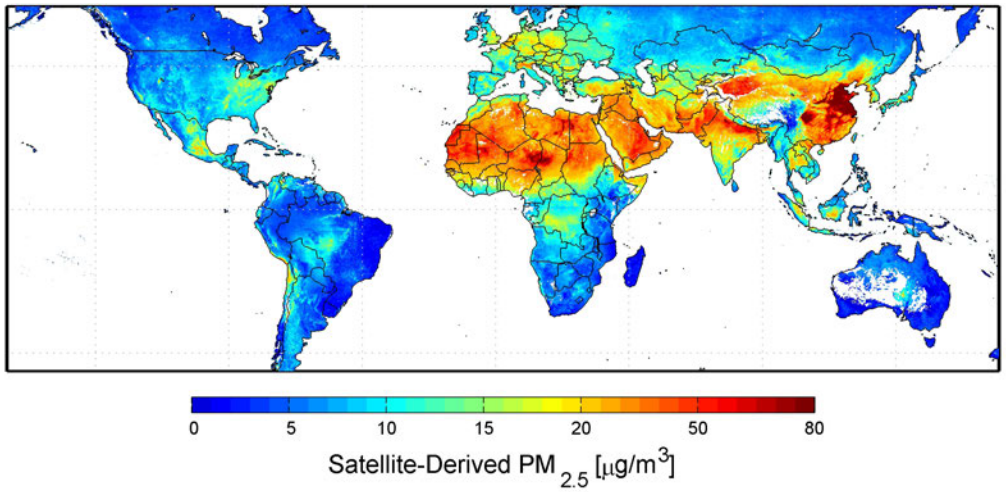


Figure 36
Source: www.google.com

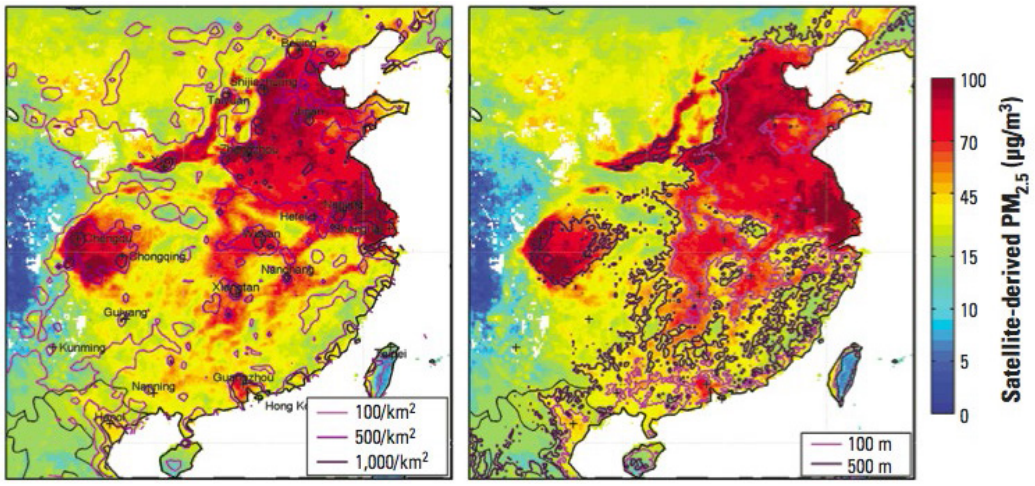


Figure 37
Source: www.google.com

TRAFFIC

Vehicles are widely used by the people who live in Beijing, and this has caused many problems. The government passed a few policies to restrict drivers. First of all, to buy a car one needs to register online. It is like lottery, there are only limited numbers of people that can buy cars. Second, based on the number of license plates, there will be days wherein the user cannot drive their vehicle in Beijing. Third, the public transportation fee is much cheaper than any other cities in China.

For most people living in Beijing, they will chose public transportation.

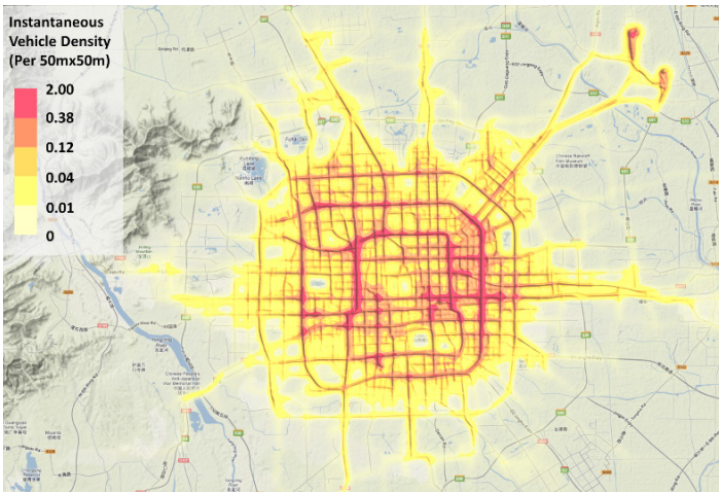


Figure 38 Instantaneous vehicle density
Source: www.google.com

Figure 39
Source: www.d3skg.com

CONTEXT

The site is located in a residential area, on the north side there are two subway stations around half a mile away. People will use the subway to get into the city and go to work. On the south side a train station is located, and the police station is also located there. Based on the style of the building and the structural material, we can see that the 5 floor apartment buildings are built in 1960's to 1970's. The 12 floor apartment tower and the 8 floor apartment tower are new apartment towers. On the north side of the site is a school. A local factory is also located here.

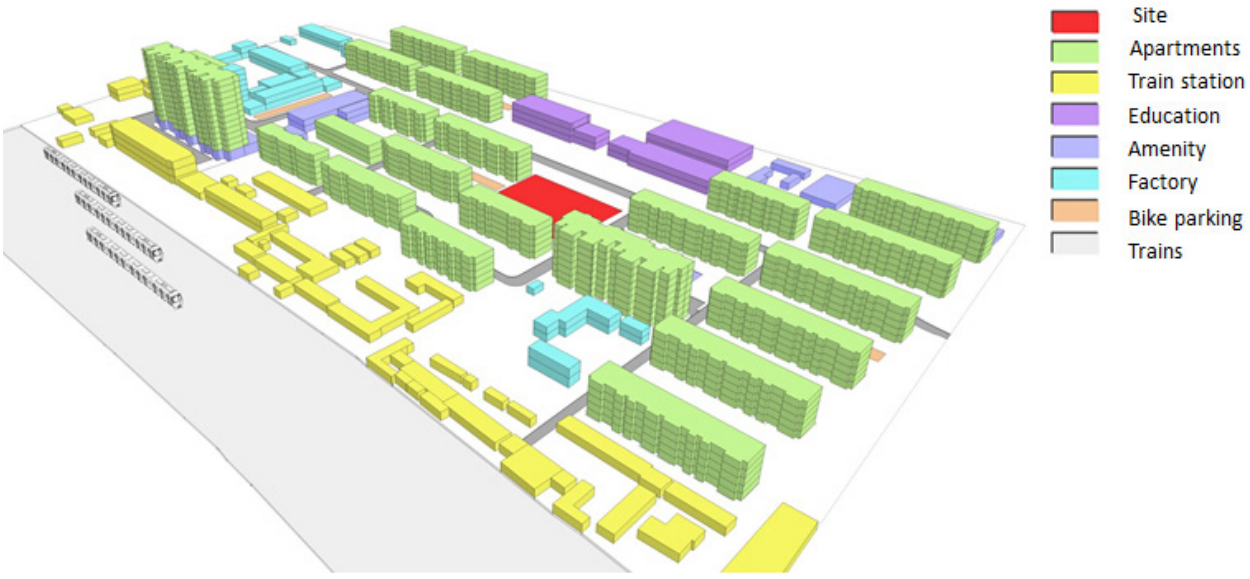


Figure 40 Context

SITE STRATEGIES

Since the public transportation station is on the north of the site, the main entrances will be on the north. Due to the train station on the south side, the higher the unit of the micro-apartment the better view it will have. Based on the code of residential building in Beijing, the micro-apartment on the site can be no more than 36 meters high. Because on the south of the site there is no green space, a garden on the south side of the building is needed. The apartment towers around the site were built half a century ago, therefore more amenity space is needed in this area. The amenity space is not only to serve the people who live in the micro-apartment but also to serve the people who live in the area. Considering it is a very old community area, restaurants and a supermarket are needed. There are lots of old people living in the community, so because of the culture we should have a plaza for them to dance and communicate. For people who live in Beijing, a bike is one of the basic tools for daily life, so a parking space for bikes should be considered.

Figure 41 Site plan

Space & Experience

Activities and Functions

Parking area

Main entrance

Courtyard

Playground

Lobby

Manager Office

Gathering space

Mechanical equipment

Power rooms

GYM

Coffee room; Tea house

Mail box

Ergonomics

In order to create a comfortable living experience for the clients in the tiny apartment, the ergonomics should be deeply considered. The term human factor encompasses both physiology and psychology and covers most factors affecting human performance of tasks using tools in man-made environments. For decades, this has been widely used in architectural design, interior design, industrial design and others. Although the micro-apartment is tiny and we need all the manner spaces in one tiny area, it does not mean we can ignore human factors. In fact, it becomes more important than usual; all spaces have to be designed smartly under "human factors".

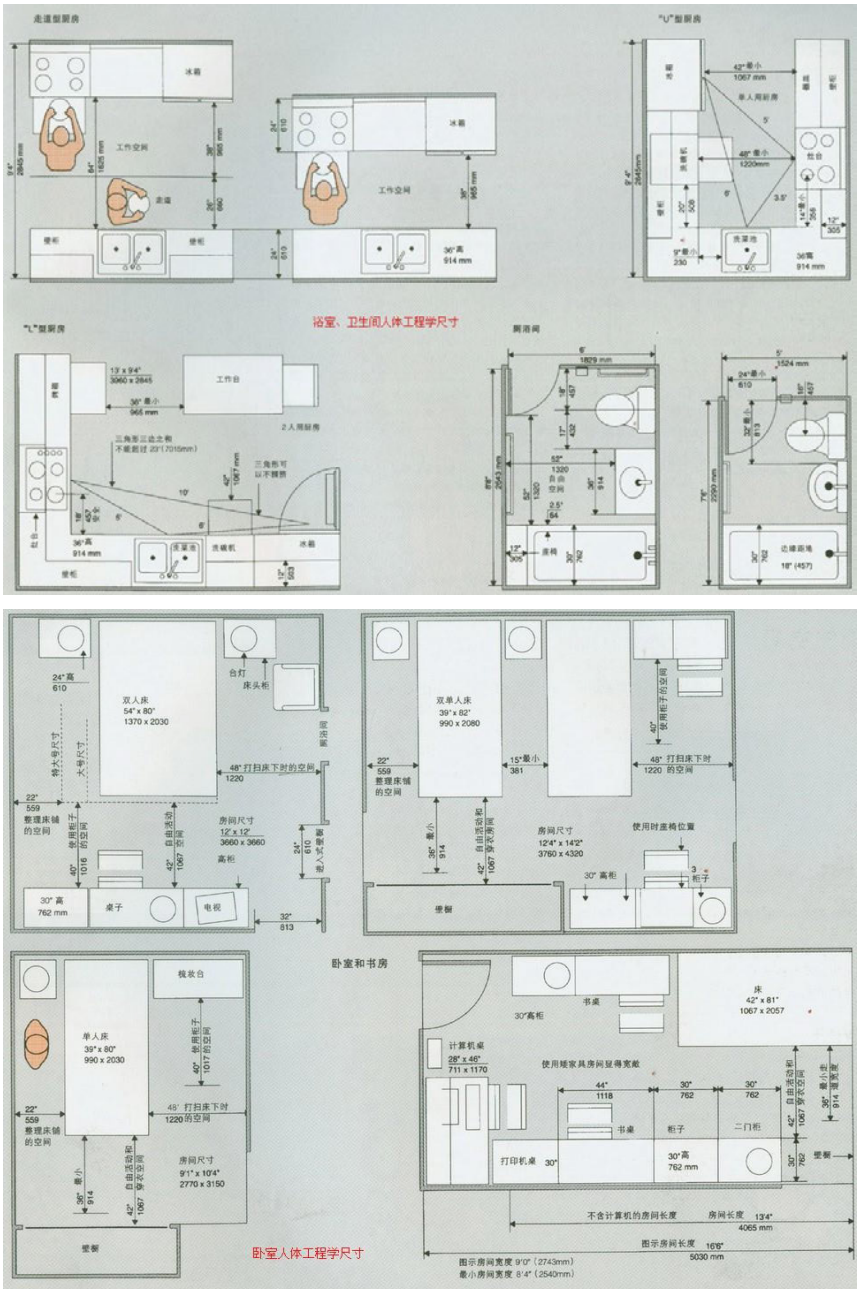


Figure 42 Ergonomics
Source: The Measure of man and woman: human factors in design, Tilley, Alvin R

SPACE STANDARDS AND CRITERIA

1. Bedroom:

Two people ≥ 10 sqm

Single people ≥ 6 sqm

Bedroom height ≥ 2.4 meter

2. Kitchen:

Kitchen table: 2.1meter by 0.6 meter

Kitchen area≥ 5 sqm

3. Door size:

Unit entrance, living room and bedroom ≥ 0.9 meter

Public entrance (building entrance and stairs) ≥ 1.2 meter

4. Window:

The ratio of window area to floor area of bedroom and living room ≥ 1/7

5. Stair: Steps:

Wide≥ 0.26 meter

Height ≤ 0.175 meter

6. Exit number:

Apartment tower less than 10 floors: area ≥ 650 sqm or unit door to stair door more than 15m _ exit ≥2

Apartment tower 10 - 18 floors: area ≥ 650 sqm_ exit ≥2

Apartment tower more than 18 floors: exit ≥2

Distance between two exits less than 40 meters.

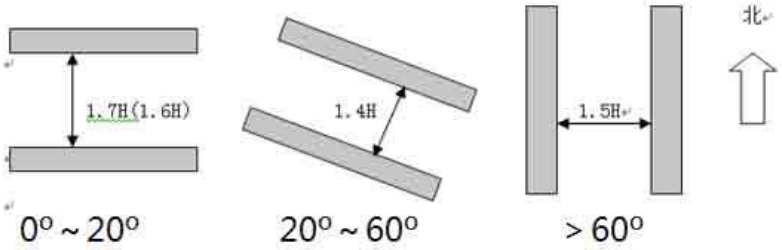
7. Elevator:

Less than 18 floors or ≤ 6 units per floor & more than 19 floors_ 2 elevators

More than 17 floors or more than 8 units per floor_ 3 elevators.

8. Distance between the buildings:

Q： when use 1.7 ?
when use 1.6 ?
when use 1.4 ?
A ：0º ~ 20º——1.7 ;
20º ~ 60º——1.4



Fire resistance rating	Fire resistance rating		
	一、二	三	四
	distance(m)		
一、二	6	7	9
三	7	8	10
四	9	10	12

Figure 43 Distance between buildings

DESIGN PRINCIPLES

Based on the research, prefabrication has many advantages for apartment building. On one hand, it can lower the budget for the building, and the modular design can shorten the entire design and construction process. It can also help locate the micro-apartment on different sites. On the other hand, the air pollution is pernicious in Beijing. As a developing country, the construction of buildings is one of the causes of air pollution. Prefabrication can help reduce the damage that is caused by construction.

The ground floor will be used as amenity, and for amenities functions which will be based on the needs of the site. The amenities will not only serve the people who live there, but also serve the people around the site. Since it is located in the metropolitan areas, amenities will differ from site to site.

In order to fulfill the space requirement, the entire structural system of the tower will be steel. Unlike the concrete structure, the walls do not have to be on the ground floor. This will help to create large open space on the ground floor. It can help to fulfill different space requirements for different functions.

Flexibility is another important element in the design. The space requirement for one person, a couple and a couple with a child will be different. In order to fulfill the needs of the clients and help the clients save money, the replaceable part of the unit will be different sizes and the client can use the transformable furniture to create the space in their home.

Another design principle is to create a large number of facade choices and for the clients to choose their own style. There will be a crane on the roof of the apartment tower so it will be easy for the clients to replace the façade in the future. This will be to make the clients feel much more comfortable living in the micro-apartment.

Design

Modular design + Prefabrication + Replaceable

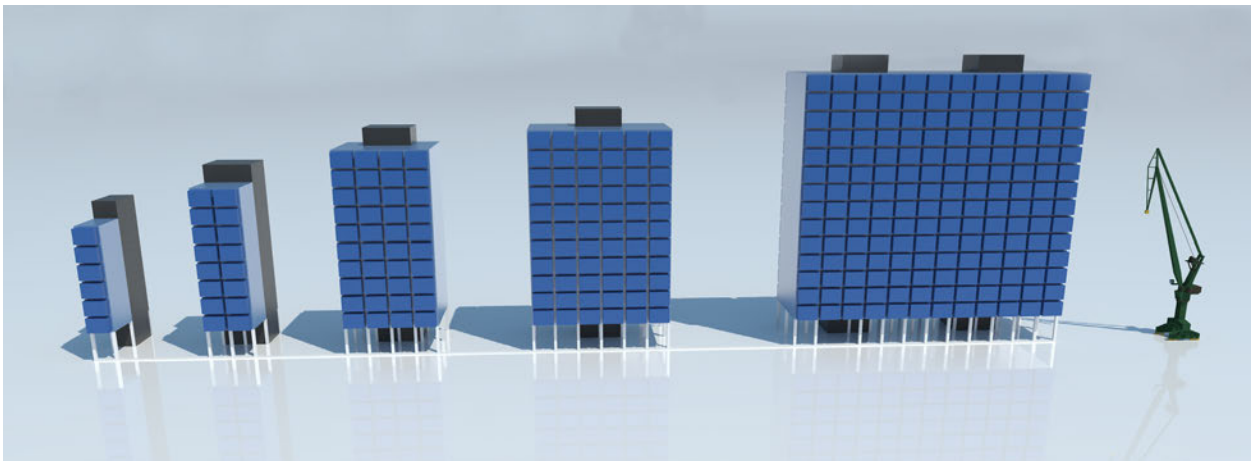


Figure 44 Design concept

GROUND FLOOR PLAN

Based on the research, in order to live in Beijing, the young people have to work very hard every day. They are often the only Child in their household, so lot of young people do not know how to cook or are incompetent at cooking. Therefore the restaurant is necessary to meet their dietary needs. In the meantime, exercise is among the basic needs for the young professional, so to have their own gym will help to keep them healthy. The manager office is the place people pay their gas, electricity and management bills. The other function rooms such as mechanical room, power rooms and storage are also located on the ground floor.

The ground floor plan is separated into two parts. On the north all the stores are open to all the customers, which means the C-store and the restaurants are also available to serve the people who live around here. But on the south side, the gym and the garden are only for the clients who live here. For security reasons, the doors which connect to the lobby will need key cards to open.

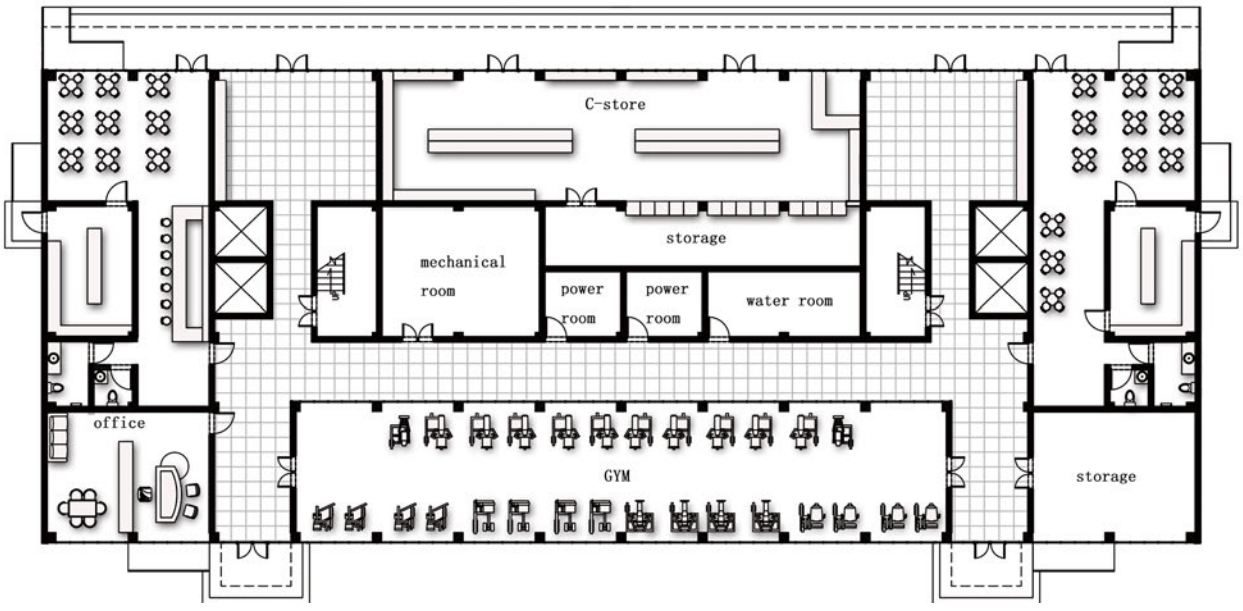


Figure 46 Ground Floor Plan

TYPICAL FLOOR PLAN

The typical floor plan is the dorm like style plan. It is all because all the units are prefabricated in the factory. The typical floor plan is also separated into two parts: fixed part and replaceable part. The fixed part cannot be replaced in the future and the replaceable part has different sizes for the customers to choose.

The bathroom and kitchen are connected to the corridor because the pipes are located in the corridor. Every unit has its own place for the pipes and the meters are inside the door. Those are all located in the fixed part.

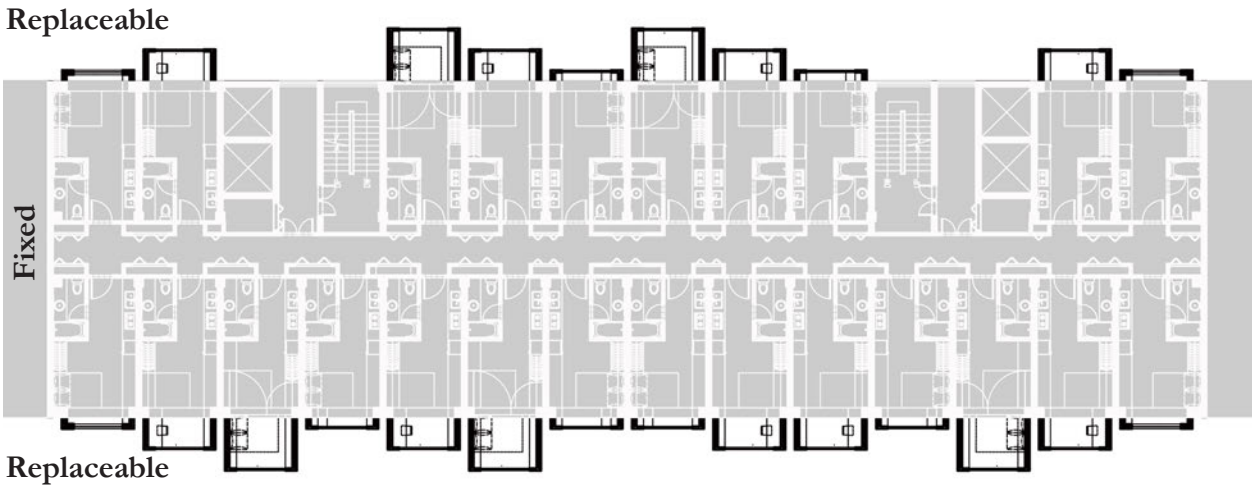


Figure 47 Floor Plan

PREFABRICATION

The prefabrication is separated into 6 steps.

Step 1: identical modules: Prefabricate the ceiling and structure in the factory

Step 2: pre-installed fixtures: Pipes and ducts are threaded through each floor module while it's still in the factory

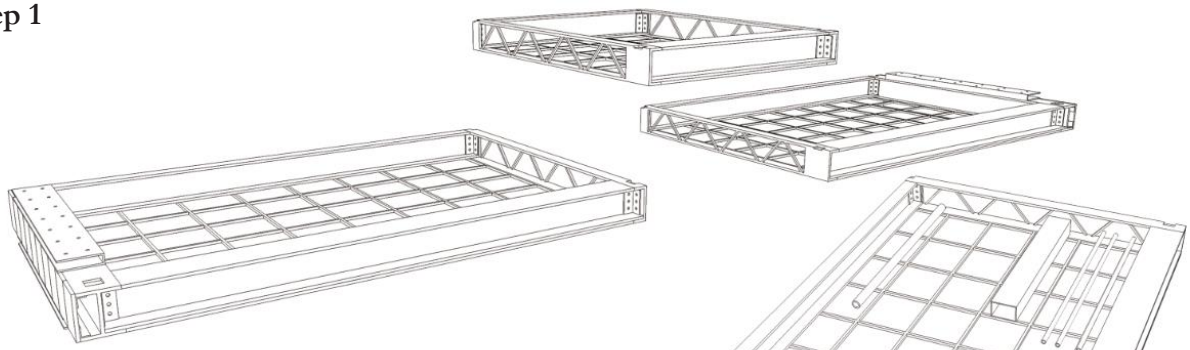
Step 3: pre-installed floor: The client's choice of flooring is laid in advance

Step 4: delivery: Modules are brought to site each with all the necessary columns, bolts, tools and other peripherals necessary for connection and installation.

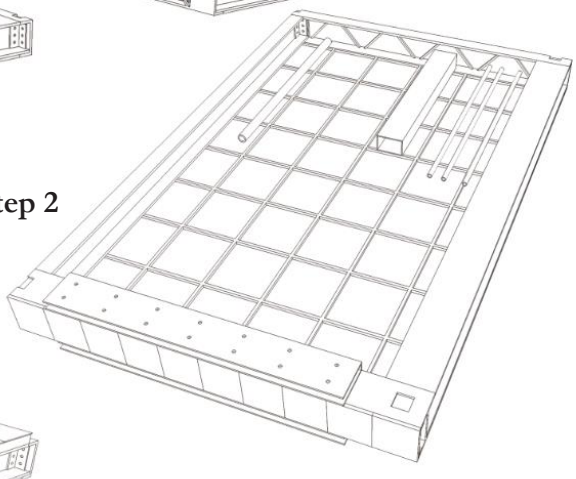
Step 5: instant assembly: Each section is lifted into place by crane. Workers use the materials on the module to connect the pipes and wires quickly.

Step 6: install windows: Delivery of the prefabricated windows to the site and quick installation.

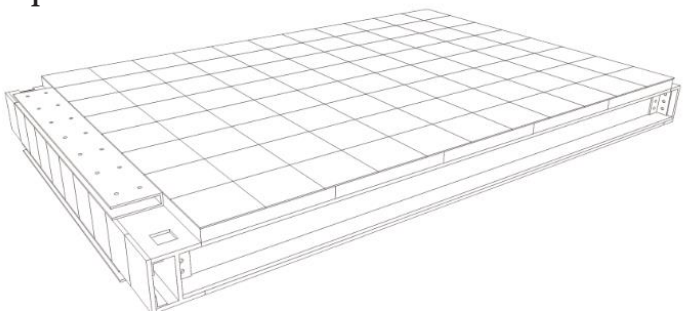
Step 1



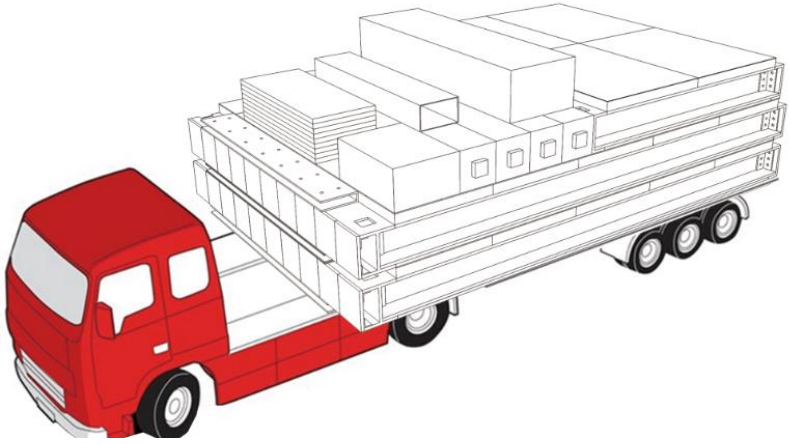
Step 2



Step 3



Step 4



Step 5

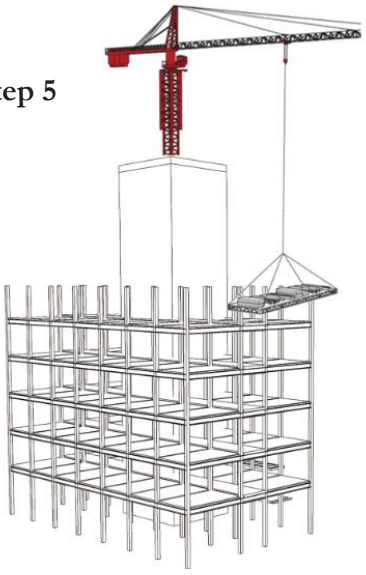


Figure 48 Prefabrication

FLEXIBILITY

To fulfill the diverse needs of clients the plugins have different sizes. The plugins are separated into single plugin and double plugin systems. The largest size of the plugin is the double plugin window, and it can be as long as 4 meters.

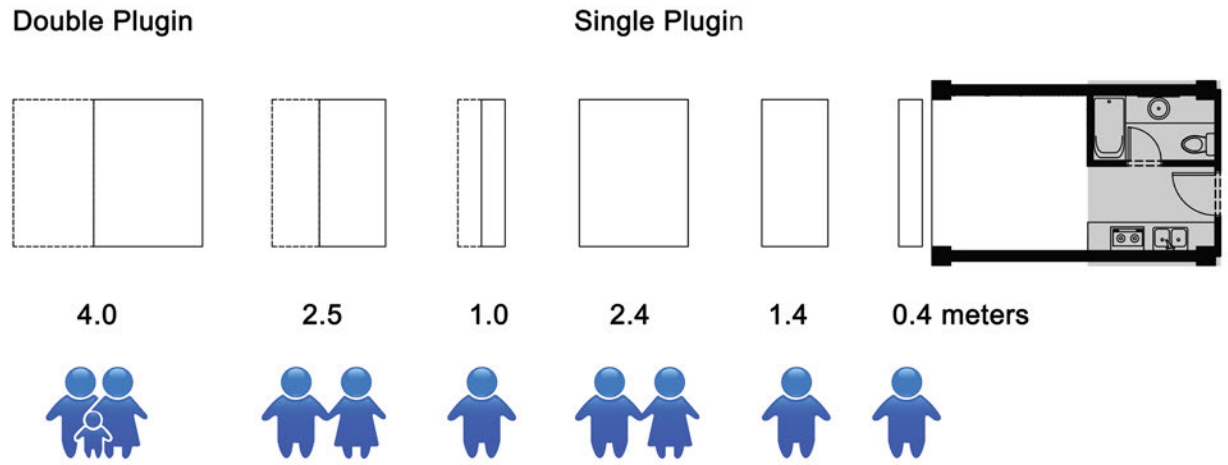


Figure 49 Plugin concept

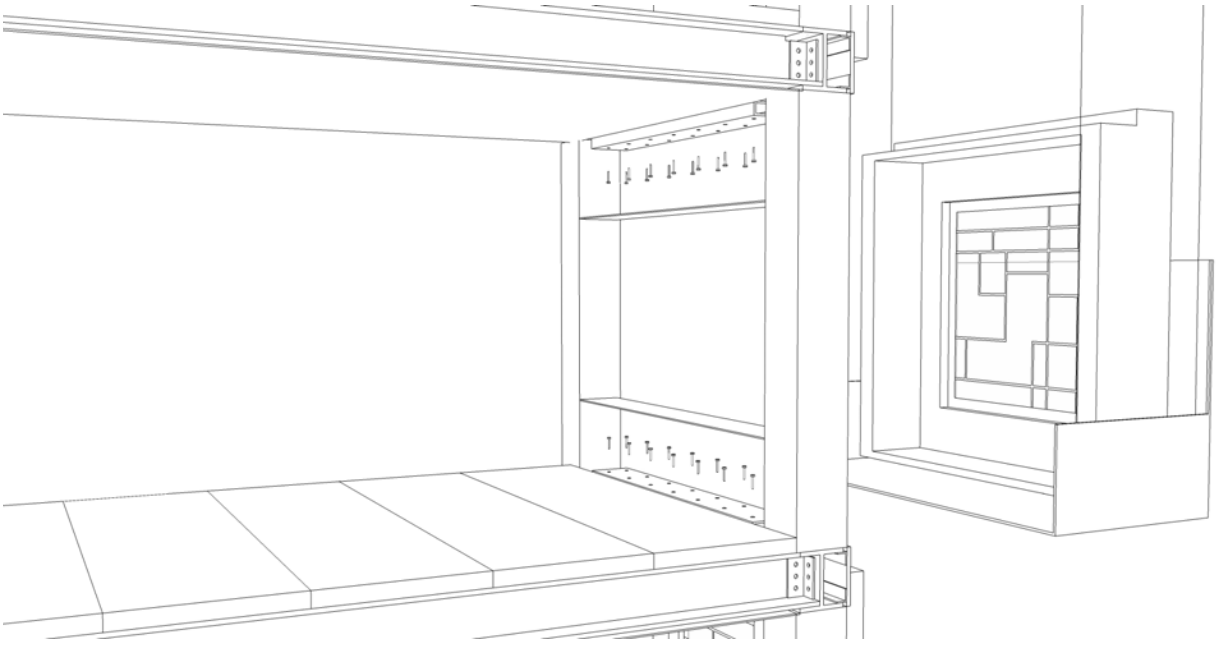


Figure 50 Plugin detail

In figure 52, the double plugin system is designed for the people who need a large living space. After the clients have children, they will consider upgrading their unit into the double plugin system. We can see the transformable furniture can help create space for the tiny unit. The desk can be transfered into a queen size bed, the screen between the two transformable beds will be used to separate the space into two bedrooms. The shelf, which is hidden, can be used after the client turns on the double plugin system and moves the sliding cabinet.

Figure 51 Double Plugin

BUILDING SECTION

In the section, we can see all the flexible parts will be installed to the units by the crane on the roof. For those single plugin systems, we use the floor and the roof material to cover the joints. So inside the unit, the clients will not see any joints. In the future, when the client wants to upgrade their unit, they can take out the material which used to cover the joints and then use the crane on the roof to uninstall the flexible part, then to install a new part. Compared to some micro-apartments which require replacing the entire unit, this design helps the client save a lot of money on replacement.

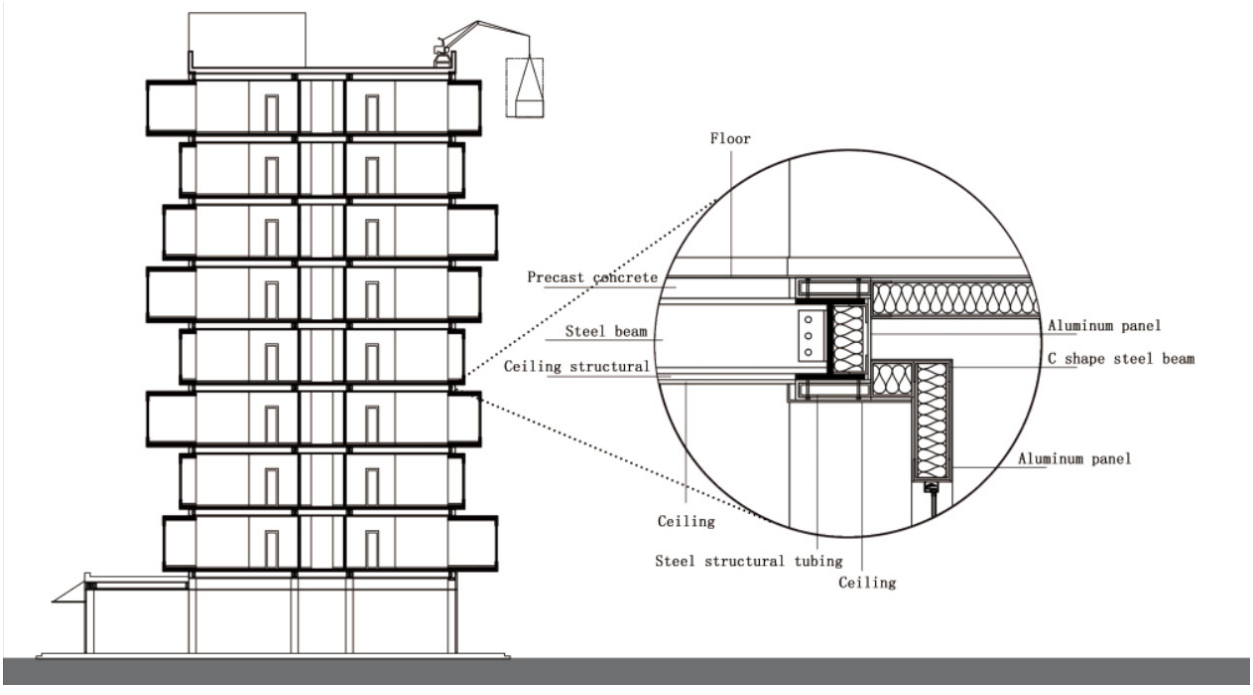


Figure 52 Building Section

FAÇADE

The façade of the unit is designed by us but chosen by the clients. The clients will chose their favorite color on the metal panel on the façade, and they can also chose different patterns on the panel. After the client chooses the color, patterns, frames and words on the façade, the unit will become a very personal design. All the panels are hung on the façade, which means they can be easily replaced in the future. One of the disadvantages of prefabrication is that all the units are the same. But in this design, we have large number of options for the client, so it can solve the problem. As the designer, we provide different design options to make sure it will become the dream home for the client.

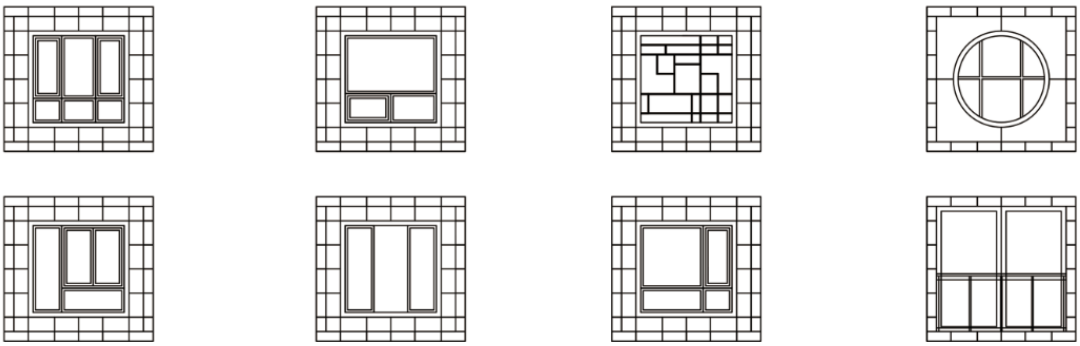


Figure 53 Facade

Inspiration images

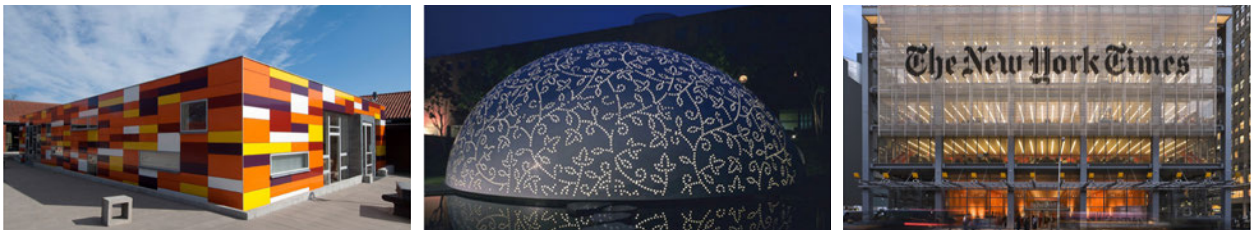


Figure 54

FURNITURE DESIGN

Inspiration images

Figure 55 Inspiration images

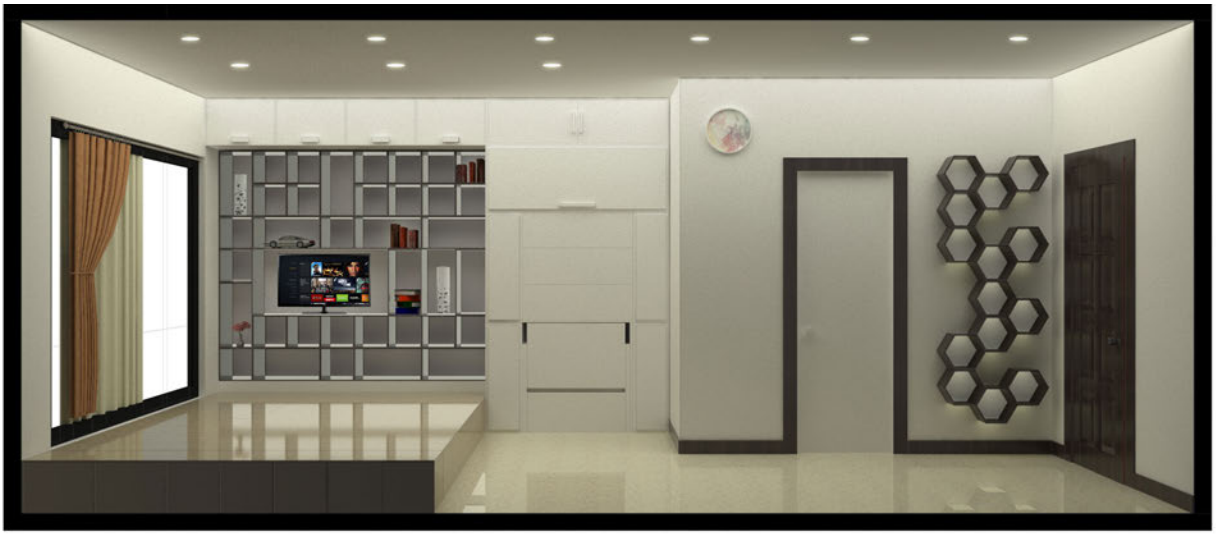


Figure 56 Single Plugin

The bed accounts for a big space in the apartment, but there are a few ways to hide the bed. In this design, I combined the slide bed with storage. Because no matter how tiny the apartment is, the storage always requires a good deal of space.

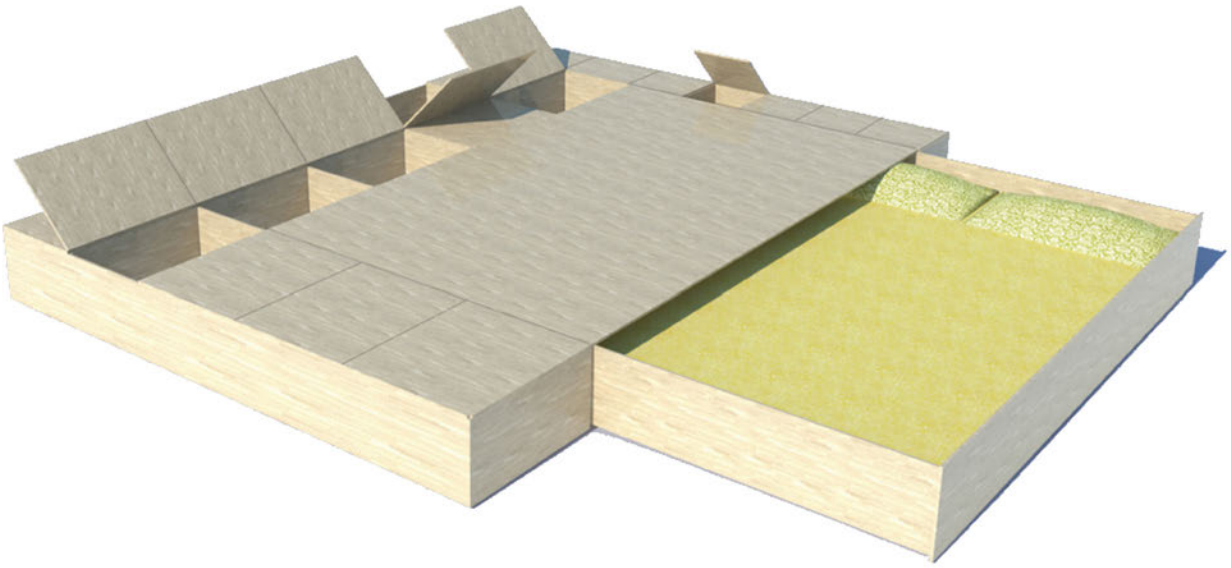


Figure 57 Single Plugin

When you open the desk, it can be your working space, dining space and storage space. When you don't need to use it, it can be one box against the wall.

Figure 58 Single Plugin

The idea is making the furniture like Lego toys, using simple units to create complex furniture.

All single units have different colors to meet the desires of the clients.

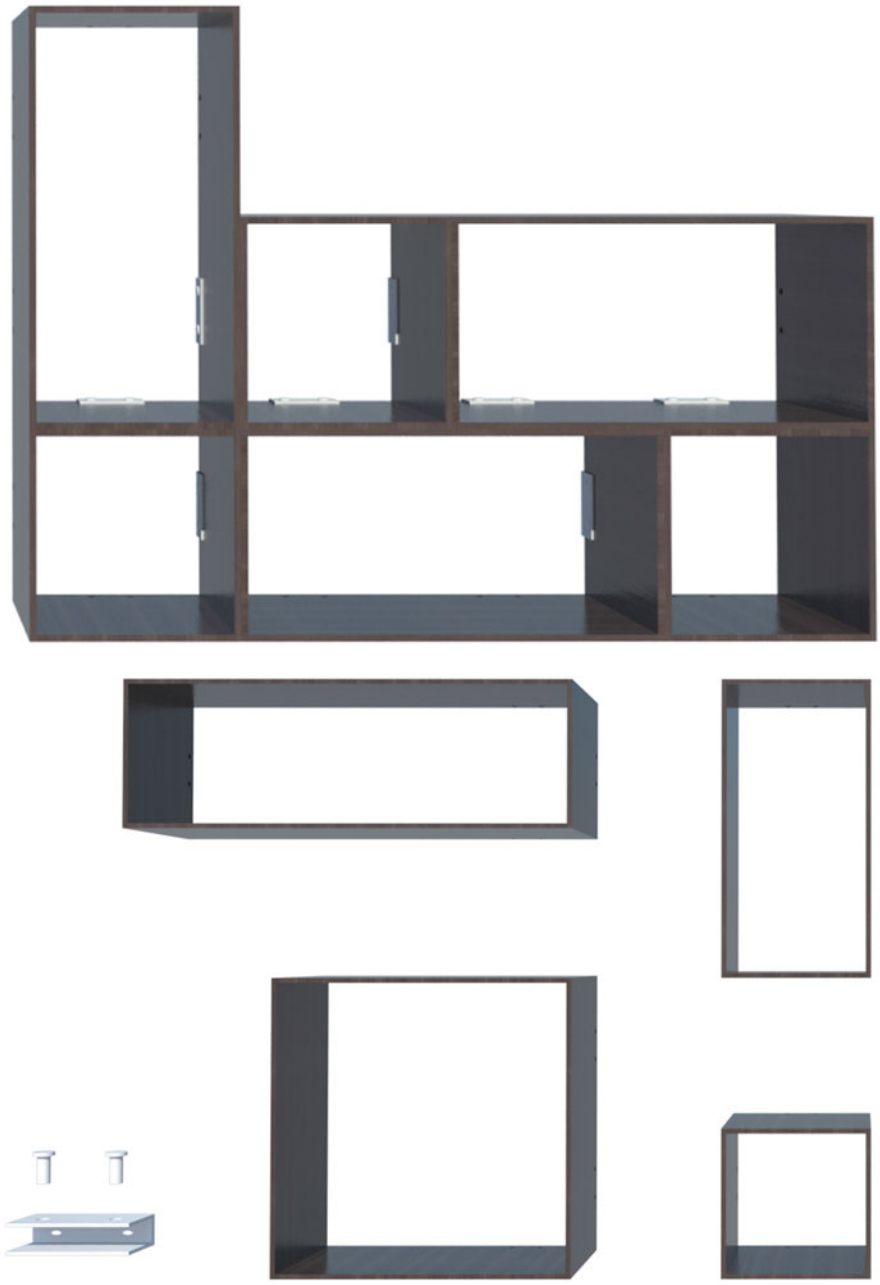


Figure 59 Single Plugin

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